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**U.S. Army  
Environmental  
Center**

**US Army  
Environmental Center**

**LEXINGTON-BLUEGRASS  
ARMY DEPOT  
GROUNDWATER INVESTIGATION  
REPORT  
PHASE I - FINAL**

**Volume I**

**Lexington-Bluegrass Army Depot  
Lexington, Kentucky**

**Submitted to:**

**Commander  
Department of the Army  
United States Army Environmental Center  
Aberdeen Proving Ground, Maryland**

**Submitted by:**

**Metcalf & Eddy, Inc.  
2800 Corporate Exchange Drive  
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Columbus, Ohio 43231**

**Prepared Under:**

**Contract No. DAAA15-90-D-0016  
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**September 1995**

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13. ABSTRACT (Maximum 200 words) The Groundwater Investigation Report, Phase I, for the Lexington-Bluegrass Army Depot (LBAD), Lexington, KY, has been prepared for the U.S. Army Environmental Center under the Base Realignment and Closure Program. The report presents the results of a Groundwater Study performed in conjunction with a RCRA Facility Investigation. The report presents the information and findings for groundwater and those media expected to affect groundwater (soil, sediment, surface water). A baseline risk assessment was performed to evaluate the possibility of human health and ecological effects in receptors potentially subject to exposure to chemicals detected in the groundwater at LBAD. Chemical contamination in the various media at LBAD includes inorganics, organics, and pesticides. Based on groundwater flow and base activities, the site was divided into northern and southern sections for risk assessment purposes. Based on a conservative risk evaluation, both the groundwater in the northern and the southern sections of LBAD possess potentially unacceptable levels of human health or ecological risk or had sampling results exceeding potential ARARs. (See reverse)				
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Section 13, over, continued

A Corrective Measures Study (CMS) portion of the Groundwater Report identifies and evaluates remedial alternatives for the chemicals identified in the groundwater which pose unacceptable risks.

**US Army  
Environmental Center**

**LEXINGTON-BLUEGRASS ARMY DEPOT  
GROUNDWATER INVESTIGATION REPORT  
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## **EXECUTIVE SUMMARY**

The Defense Secretary's Commission on Base Realignment and Closure (BRAC) was chartered in May 1988. In October 1988, Congress expanded the Commission's mandate by requiring the Secretary of Defense to implement the Commission's Final Recommendations. In December 1988, the Commission identified the Lexington-Bluegrass Army Depot (LBAD) for closure. LBAD is located on approximately 782 acres of land in Fayette and Bourbon Counties, in the town of Avon, approximately 10 miles east of Lexington, Kentucky.

As mandated, base realignment and closures must comply with applicable environmental laws. Closure of LBAD cannot occur until the potential effects remaining from use of any hazardous and toxic materials have been evaluated and a statement of condition issued by the United States Army Environmental Center (USAEC) (formerly USATHAMA) (the organization designated as the certifying agent of the U.S. Army). The performance of an environmental investigation allows USAEC to identify the presence and extent of any on-site contamination and associated public health and environmental risks.

This document presents the results of a Phase 1 Groundwater Study performed in conjunction with a RCRA Facility Investigation conducted during the period of October 1991, through July 1994 at LBAD. Specifically, this report presents information and findings only for groundwater and those media expected to affect groundwater (soil, sediment, and surface water), and describes the procedures used to conduct the Phase 1 Groundwater Study, to assess the results of the study, and to recommend further actions, if necessary.

As previously stated, the Phase 1 Groundwater Study was conducted in conjunction with the RCRA Facility Investigation (RFI)/Corrective Measures Study (CMS). In order to expedite the completion of the RFI/CMS and to further evaluate the groundwater flow regime at LBAD, groundwater was addressed as a separate operable unit (a CERCLA term agreed upon for this site). The Phase 1 RFI was issued as a Final Document in August, 1995, and the CMS was issued as a Draft Final Document in June 1994.

Field activities consisted of the collection of 104 soil borings, four rock corings, a soil gas survey, the installation and sampling of 39 monitoring wells, the installation of four piezometers, slug testing of 18 wells, a 50-hour pumping test, a dye trace test, and a water usage survey.

The Lexington area is near the crest of the Cincinnati Arch, a broad, low structural feature whose long axis extends generally northward from Tennessee through central Kentucky and western Ohio into southern Michigan. The area is underlain by essentially flat-lying rocks of Ordovician Age, consisting chiefly of alternating beds of limestone and shale belonging to the Lexington Limestone.

LBAD is in the east-central part of a 5,600 square mile area, termed the Inner Bluegrass Karst Region. Karst is defined as a type of topography formed on limestone and other rocks of dissolution and is characterized by sinkholes and underground drainage (Bates and Jackson, 1980). The aquifer at LBAD can be described as an immature karst aquifer with water occurring in a network of generally interconnected fractures and minor solution openings that may be isolated locally from each other. The fractures and solution openings become more numerous and better integrated downgradient and within more soluble formations, but generally decrease with depth. The flow system at LBAD can best be described as one aquifer occurring at three degrees of development across the site generally north to south. These degrees of development consist of: (1) top of rock flow; (2) a highly transmissive zone within Tanglewood formation (a formation of the Lexington Limestone); and (3) a more highly developed transmissive zone with both the Tanglewood Formation and the underlying Grier Formation (also a formation within the Lexington Limestone) in the lower most topographic areas of the site.

The nature and extent of contamination present in the groundwater at LBAD includes inorganics, organics, and pesticides. Table ES-1 summarizes those constituents present above MCLs and/or site background concentrations.

The groundwater data at LBAD was divided into a northern and southern study area based on groundwater flow and base activities. The northern portion includes Area C and the New Landfill. The southern portion includes Area B, the Old landfill, the Industrial and Sanitary Waste Landfill, and the Industrial Waste Lagoons.

The chemicals of potential concern, that is to say, the chemicals carried through the risk assessment, in each portion are as follows:

Northern Portion:

Aluminum  
Arsenic  
Barium  
Beryllium  
Boron  
Calcium  
Chromium  
Iron  
Lead  
Magnesium  
Manganese

Mercury  
Nickel  
Potassium  
Sodium  
Thallium  
Vanadium  
Acetone  
Benzene  
Chloroethane  
1,3-Dimethylbenzene  
Toluene

Southern Portion:

Aluminum  
Antimony  
Arsenic  
Barium  
Beryllium  
Boron  
Cadmium  
Calcium  
Chromium  
Cobalt  
Copper  
Iron  
Lead  
Magnesium  
Manganese  
Mercury  
Molybdenum  
Nickel  
Potassium  
Sodium  
Tellurium  
Thallium  
Tin

Vanadium  
Zinc  
Acetone  
Benzene  
Bis(2-ethylhexyl)phthalate  
Carbon tetrachloride  
1,1-Dichloroethene  
1,2-Dichloroethenes  
2,4-Dimethylphenol  
1,3-Dimethylbenzene  
Alpha-endosulfan  
Ethylbenzene  
Methyl Isobutyl Ketone  
Phenol  
Tetrachloroethene  
Toluene  
Trichloroethene  
Vinyl Chloride  
Xylenes  
Alpha-BHC  
Delta-BHC  
DDT  
Undane

Upon completion of the risk assessment, the chemicals which presented an unacceptable human health risk for each portion were further evaluated in the Corrective Measure Study. The risk-based chemicals of concern identified for remediation at LBAD include: arsenic, beryllium, lead, manganese, sodium and thallium in the northern portion; and antimony, arsenic, aluminum, beryllium, lead, manganese, thallium, and vinyl chloride in the southern portion.

A risk assessment was performed to evaluate the possibility of human health effects in receptors potentially subject to exposure to chemicals detected in groundwater from the LBAD. The risk assessment was conducted in accordance with applicable U.S. EPA and Kentucky Department of Environmental Protection (KDEP) guidelines concerning the performance of risk assessments. Conservative assumptions were employed to provide estimates of exposures, risks, and hazards which would likely result in over-estimates rather than under-estimates of the true risks and hazards for the receptor populations.

An exposure assessment was performed for each receptor group to determine whether the chemical concentrations in the groundwater would result in a daily intake level or dose which could be associated with an adverse health effect. The LBAD and surrounding area are zoned for general rural or industrial use. It is expected that the present land use designations will continue into the future. With respect to current land use, receptor population groups were identifiable. Two hypothetical future land use receptor groups were identified: potential future workers and potential future residents.

Potential exposure pathways evaluated for these receptors included: ingestion of groundwater, dermal contact with groundwater, inhalation of groundwater during showering. Exposure concentrations for the chemicals evaluated were based on the sampling results from either the northern or southern groundwater wells investigated.

A risk characterization was conducted for the chemicals selected for evaluation in which the exposure levels calculated in the exposure assessment were evaluated with respect to the toxicity values identified in the toxicity assessment. The approach taken in the risk assessment was one where conservative assumptions were employed to err on the side of over-estimating exposures, risks, and hazards. Risk management decisions for the LBAD should include a thorough evaluation of such uncertainties. Based on this evaluation, estimated hazard indices exceeded unity in both the northern and southern groundwater wells at the LBAD. The primary chemicals contributing to the excess hazard were: (1) arsenic, lead, manganese, sodium, and thallium in the northern LBAD area; and (2) antimony, manganese, aluminum, lead and thallium in the southern LBAD area.

The risk estimates for the groundwater areas evaluated for the LBAD were within this criterion range, with the following exceptions where risk exceeded  $1.0E-06$ : (1) potential exposure to arsenic and beryllium in the northern area of the LBAD; and (2) potential exposure to arsenic beryllium, and vinyl chloride in the southern area of the LBAD.



The Corrective Measures Study (CMS) portion of this report identifies and evaluates remedial alternatives for the chemicals of concern which have been identified in the LBAD groundwater. Chemicals of concern are defined in the CMS as the chemicals detected in the LBAD groundwater which present an unacceptable risk to human health or exceed Federal USEPA or State of Kentucky cleanup standards, standards of control, or other potentially relevant criteria/guidelines for human health and/or environmental protection<sup>1</sup>. The CMS was prepared in accordance with the USEPA guidance provided in the document entitled "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA, 1988).

In performing the CMS, preliminary cleanup goals were developed for the contaminants of concern in the LBAD groundwater. These cleanup goals represent the concentrations to which the chemicals of concern should be reduced in order to achieve acceptable human health and environmental risks and to provide compliance with regulatory requirements. In accordance with "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA, 1988a), the cleanup goals and Applicable or Relevant and Appropriate Requirements (ARARs) were used to develop remedial action objectives for the LBAD groundwater. General response actions were then developed for the chemicals of concern in the LBAD groundwater to satisfy the remedial action objectives. Remedial technologies/alternatives applicable to each general response action were then identified and screened to select the alternatives considered most appropriate for the LBAD groundwater contaminants. The three remedial alternatives which passed the initial screening process and selected for detailed evaluation in the CMS include the following:

- Alternative I - No Action
- Alternative II - Institutional Controls/Long-Term Monitoring
- Alternative III - Groundwater Treatment

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<sup>1</sup> The only noted exceptions to this definition are DDT, bis(2-ethylhexyl)phthalate, carbon tetrachloride, tetrachloroethene, and trichloroethene. DDT was detected in only 3 out of 42 groundwater samples at concentrations which were generally consistent with background concentrations. Bis(2-ethylhexyl)phthalate, carbon tetrachloride, and tetrachloroethene were detected in only 1 out of 44 samples at concentrations which were close to or below USEPA MCLs and the State of Kentucky Water Supply Source Criteria Values. Trichloroethene was detected slightly above the USEPA MCL and the State of Kentucky Water Supply Source Criteria Value for trichloroethane in only 1 out of 44 samples. The results of the risk assessment for the LBAD groundwater determined that the detected concentrations of all these chemicals did not present an unacceptable risk to human health.

**TABLE ES-1a Summary of Constituents Present in the Groundwater at the Old Landfill above MCLs**

PARAMETER	MCL UG/L	S004MW0200 12/10/91	S004MW0300 12/10/91	S004MW0400 12/4/91	S004MW0400 9/2/92	S004FD0500 12/9/91	S004MW4700 8/21/92
Aluminum	50-200	992	1360	22900	2710	526	44200
Antimony	6	ND	ND	63	ND	ND	ND
Boron	-	ND	ND	ND	ND	ND	967
Calcium	-	130000	80600	172000	69700	102000	26600
Cobalt	-	ND	ND	32.8	ND	ND	ND
Copper	1000	24.2	30.9	41.1	ND	23.1	57.2
Iron	300	3590	3970	51200	5580	2180	39100
Lead	15	21.8	9.12	101	9.65	ND	106
Magnesium	-	36600	9870	18400	15000	13600	6440
Manganese	50	182	74.2	1000	361	193	324
Potassium	-	4860	1690	5310	2700	1510	7690
Sodium	-	47000	69000	27800	75000	13000	180000
Vanadium	-	ND	ND	39.8	ND	ND	34.1
1,3-Dimethylbenzene	-	3.7	ND	ND	ND	ND	14
Acetone	-	ND	ND	ND	ND	ND	>100

**TABLE ES-1a Summary of Constituents Present in the Groundwater at the Old Landfill above MCLs**

PARAMETER	MCL UG/L	S004MW1900 5/26/92	S004FD1900 5/26/92	S004MW1900 9/10/92	S004MW4200 8/19/92	S004FD4200 8/19/92
Aluminum	50-200	1220	1560	350000	289	322
Antimony	6	ND	ND	217	ND	ND
Beryllium	4	ND	ND	18.2	ND	ND
Calcium	-	88400	89500	*	78200	81100
Chromium	100	ND	ND	448	ND	ND
Cobalt	-	ND	ND	188	ND	ND
Iron	300	3060	3600	342000	2380	2590
Magnesium	-	13900	14300	980000	11600	12000
Manganese	50	252	270	65000	124	129
Molybdenum	-	ND	ND	58.8	ND	ND
Nickel	100	ND	ND	427	ND	ND
Potassium	-	ND	1660	53500	1630	1780
Sodium	-	12800	13900	*	20800	21100
Tellurium	-	ND	ND	211	ND	ND
Thallium	2	ND	ND	437	ND	ND
Tin	-	ND	ND	62.9	ND	ND
Vanadium	-	ND	ND	237	ND	ND
2-Hexanone	-	ND	ND	5.3 R	ND	ND
1,3-Dimethylbenzene	-	ND	ND	ND	ND	1.14
2,4-Dimethylphenol	-	ND	ND	20	ND	ND
Methyl Isobutyl Ketone	-	ND	ND	5.3	ND	ND

**Key:**

All results are in ug/l

ND - Not Detected

U - Unconfirmed Analysis

R - Analysis required for reporting purposes but not certified

\* - This concentration for sodium is > 220000 ug/l; concentrations for calcium is > 270000 ug/l

TABLE ES-1b Summary of Constituents Present in the Groundwater at the New Landfill above MCLs						
PARAMETER	MCL UG/L	S001MW1134 12/5/91	S001MW2300 8/19/92	S001MW23D0 8/19/92	S001MW43I0 8/19/92	S001MW44I0 8/19/92
Aluminum	50-200	22900	17000	10800	1060	1980
Boron	-	ND	ND	ND	535	450
Calcium	-	174000	510000	*	139000	55900
Iron	300	53400	29600	17100	1560	1180
Lead	15	18.6	62.7	30	ND	ND
Magnesium	-	54600	46200	920000	19300	29700
Manganese	50	1700	935	1330	70.3	34.5
Potassium	-	25200	11900	154000	9250	31100
Sodium	-	*	110000	*	120000	62000
Thallium	2	189	ND	ND	ND	ND
Vanadium	-	36.9	ND	ND	ND	ND
1,3-Dimethylbenzene	-	ND	1.4	4.3	ND	ND
Acetone	-	ND	ND	ND	>100	ND

**Key:**

All results are in ug/l

ND - Not Detected

H - Out of control but data accepted due to high recoveries

S - Results based on internal standards

(1) - Results less than CRL but greater than Criteria of Detection (COD)

**TABLE ES-1d Summary of Constituents Present in the Groundwater at the Industrial Waste Lagoons above MCLs**

PARAMETER	MCL UG/L	S003MW0600 12/11/91	S003MW1051 11/24/91	S003MW1051 9/1/92	S003MW4100 8/19/92	S003MW1052 12/6/91	S003FD1052 12/6/91
Aluminum	50-200	2470	3500	ND	655	34400	ND
Boron	-	ND	ND	588	408	ND	ND
Cadmium	5	ND	7.22	ND	ND	343	ND
Calcium	-	165000	118000	95300	88200	240000	ND
Chromium	100	28.7	18.1	ND	ND	173	ND
Cobalt	-	ND	ND	ND	ND	28	ND
Iron	300	3200	8940	524	793	152000	ND
Lead	15	ND	5.55	ND	ND	27.1	32.1
Magnesium	-	54200	31200	29600	9830	55300	ND
Manganese	50	305	342	150	1060	5870	ND
Nickel	100	ND	ND	ND	ND	111	ND
Potassium	-	6180	4940	3520	2530	12000	ND
Sodium	-	48900	29200	21800	15400	40100	ND
Vanadium	-	ND	ND	ND	ND	53.8	ND
Alpha-Benzene Hexachloride	-	0.009 U	0.004 U	ND	ND	0.003 C	0.008 U
DDT	-	6.012 C	ND	ND	ND	0.017 U	0.017 U
1,3-Dimethylbenzene	-	1.8	ND	ND	ND	ND	ND
Acetone	-	52	52	ND	ND	ND	ND
Bis(2-ethylhexyl) phthalate	-	ND	ND	ND	ND	13	ND
Phenol	-	ND	ND	ND	ND	5.5	ND

**TABLE ES-1d (cont.) Summary of Constituents Present in the Groundwater at the Industrial Waste Lagoons above MCLs**

PARAMETER	MCL UG/L	S003MW1052 9/2/92	S003FD1052 9/2/92	S003MW1053 11/24/91	S003MW1600 12/10/91	S003MW1600 9/2/92	S003MW6D00 8/21/92
Aluminum	50-200	9840	9150	143	2390	262	87600
Beryllium	4	ND	ND	ND	ND	ND	36.5
Boron	-	257	274	ND	ND	271	1930
Cadmium	5	147	291	ND	ND	ND	ND
Calcium	-	153000	180000	93900	141000	107000	*
Chromium	100	41.8	119	ND	ND	ND	273
Cobalt	-	ND	ND	ND	ND	ND	25.1
Iron	300	18600	47100	1020	19300	1570	111000
Lead	15	6.71	14.6	ND	9.32	ND	470
Magnesium	-	30600	32700	38200	35000	32400	750000
Manganese	50	1810	4000	42.3	377	141	17000
Nickel	100	39.7	79.6	ND	ND	ND	152
Potassium	-	3610	5350	4280	5090	4010	122000
Sodium	-	31200	31600	32900	19600	40600	*
Thallium	2	ND	ND	ND	196	ND	ND
Tin	-	ND	ND	ND	ND	ND	94.9
Vanadium	-	ND	ND	ND	ND	ND	523
Alpha-Endosulfan	-	ND	ND	ND	ND	ND	ND
1,3-Dimethylbenzene	-	ND	ND	ND	>0.5	ND	ND
2,4-Dimethylphenol	-	ND	ND	ND	ND	ND	14
Acetone	-	ND	ND	ND	ND	ND	13
Benzene	5	ND	ND	ND	ND	ND	>100

**TABLE ES-1d (cont.) Summary of Constituents Present in the Groundwater at the Industrial Waste Lagoons above MCLs**

PARAMETER	MCL UG/L	S003MW3900 8/21/92	S003MW4000 8/20/92	S003FD4000 8/20/92	S003MW4000 8/21/92	S003FD4000 8/21/92
Aluminum	50-200	94800	666	746	2520	1820
Beryllium	4	36.5	ND	ND	ND	ND
Boron	-	2420	587	593	1110	1180
Calcium	-	*	115000	93200	131000	115000
Chromium	100	210	ND	ND	ND	ND
Cobalt	-	69	ND	ND	ND	ND
Iron	300	135000	1680	1260	4080	2580
Lead	15	180	ND	ND	ND	ND
Magnesium	-	830000	37500	26900	43000	46600
Manganese	50	14000	157	142	292	201
Nickel	100	169	ND	ND	ND	ND
Potassium	-	125000	5680	5410	10900	12000
Sodium	-	*	48900	57800	190000	220000
Tin	-	102	ND	ND	ND	ND
Vanadium	-	523	ND	ND	ND	ND
1,3-Dimethylbenzene	-	1.6	ND	ND	ND	ND
Acetone	-	>100	ND	ND	ND	ND
Carbon Disulfide	-	ND	ND	ND	5.6 R	ND

Key:

All results are in ug/l

ND - Not Detected

\* - This concentration for sodium is > 48900 ug/l



**TABLE ES-1c Summary of Constituents Present in the Groundwater at the Industrial and Sanitary Waste Landfill above MCLs**

PARAMETER	MCL UG/L	S2567MW080 12/16/91	S2567MW090 12/17/91	S2567MW122 12/6/91	S2567MW124 12/11/91	S2567MW450 8/21/92	S2567MW180 12/17/91
Aluminum	50-200	1730	952	3000	4340	171	2870
Boron	-	ND	ND	ND	ND	276	ND
Calcium	-	143000	82800	68000	129000	79800	115000
Iron	300	2190	1240	9170	6580	132	1600
Lead	15	ND	ND	ND	12	ND	15.3
Magnesium	-	18900	36700	17400	12800	24200	35400
Manganese	50	425	187	727	1680	53.2	258
Potassium	-	3210	6980	3050	2810	6310	4500
Sodium	-	41200	36100	13600	17100	29300	44900
Delta-benzene Hexachloride	-	0.011 U	0.007 U	ND	ND	ND	0.015 C
1,1-Dichloroethane	-	9	ND	ND	ND	ND	ND
1,3-Dimethylbenzene	-	ND	1.1	ND	ND	ND	ND
Acetone	-	ND	ND	ND	ND	ND	ND
Carbon Disulfide	-	ND	ND	ND	ND	ND	>100
Vinyl Chloride	2	ND	ND	ND	ND	7.9 R	ND

**TABLE ES-1c Summary of Constituents Present in the Groundwater at the Industrial and Sanitary Waste Landfill above MCLs**

PARAMETER	MCL UG/L	S2567MW180 8/22/92	S2567MW18D 8/19/92	S2567FD18D 8/19/92	S2567MW320 8/19/92	S2567MW32D 8/21/92	S2567MW460 8/22/92
Aluminum	50-200	279	187	258	9040	270000	272
Beryllium	4	ND	ND	110	ND	28.3	ND
Boron	-	471	ND	ND	ND	712	258
Calcium	-	99500	670000	760000	270000	*	74400
Chromium	100	ND	ND	ND	27	119	ND
Cobalt	-	ND	ND	ND	ND	211	ND
Copper	1000	ND	ND	ND	ND	237	ND
Iron	300	148	335	414	18100	58400	235
Lead	15	6.38	ND	ND	18.2	ND	ND
Magnesium	-	33400	490000	550000	54200	540000	20100
Manganese	50	235	99.7	102	1240	58000	50.8
Nickel	100	ND	ND	ND	34.6	489	ND
Potassium	-	11200	74200	75900	22800	48500	3570
Sodium	-	43100	*	*	48300	*	820000
Tin	-	ND	ND	ND	ND	76.1	ND
Vanadium	-	ND	ND	ND	31.2	208	ND
1,3-Dimethylbenzene	-	16	16	13	ND	5.8	ND
2,4-Dimethylphenol	-	14.8	14.8	20.5	ND	ND	ND
Acetone	-	ND	ND	ND	ND	ND	ND
Benzene	5	1.9	1.9	1.5	ND	>100	ND
Vinyl Chloride	2	ND	ND	ND	>150	ND	ND

**TABLE ES-1c Summary of Constituents Present in the Groundwater at the Industrial and Sanitary Waste Landfill above MCLs**

PARAMETER	MCL UG/L	S2567MW330 8/19/92	S2567FD330 8/19/92	S2567MW8DQ 8/22/92	B004MW4700 9/9/93	B018MW4800 9/21/93	B018MW48D 9/21/93
Aluminum	50-200	4400	2730	512	ND	ND	ND
Boron	-	ND	ND	613	ND	ND	ND
Calcium	-	190000	165000	169000	ND	ND	ND
Iron	300	8630	6660	7910	ND	ND	ND
Lead	15	25.8	17.1	ND	ND	ND	ND
Magnesium	-	43300	40400	20000	ND	ND	ND
Manganese	50	418	337	626	ND	ND	ND
Potassium	-	10200	6620	2470	ND	ND	ND
Sodium	-	49800	46800	38400	ND	ND	ND
2-Hexanone	-	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	-	ND	ND	22	ND	ND	1.1 S
1,2-Dichloroethenes	70-100	ND	ND	34	ND	ND	ND
1,3-Dimethylbenzene	-	4	6.8	ND	16	ND	1.2
Benzene	5	ND	0.93	ND	ND	>100	230
Carbon Disulfide	-	ND	ND	ND	ND	7.3 S	ND
Trichloroethene	5	ND	ND	6.8	ND	ND	ND

Key:  
 All results are in ug/l  
 ND - Not Detected  
 U - Unconfirmed Analysis  
 C - Confirmed Analysis  
 R - This analysis is required for reporting purposes but not certified  
 \* - This concentration for calcium is >270000 ug/l; concentrations for sodium are >48300 ug/l

TABLE ES-1d Summary of Constituents Present in the Groundwater at the Industrial Waste Lagoons above MCLs

PARAMETER	MCL UG/L	S003MW0600 12/11/91	S003MW1051 11/24/91	S003MW1051 9/1/92	S003MW4100 8/19/92	S003MW1052 12/6/91	S003FD1052 12/6/91
Aluminum	50-200	2470	3500	ND	605	34400	ND
Boron	-	ND	ND	558	438	ND	ND
Cadmium	5	ND	7.22	ND	ND	343	ND
Calcium	-	165000	118000	95300	88200	240000	ND
Chromium	100	28.7	18.1	ND	ND	173	ND
Cobalt	-	ND	ND	ND	ND	28	ND
Iron	300	5200	8940	524	793	162000	ND
Lead	15	ND	5.55	ND	ND	27.1	32.1
Magnesium	-	54200	31200	29600	9930	55300	ND
Manganese	50	308	342	150	1060	6870	ND
Nickel	100	ND	ND	ND	ND	111	ND
Potassium	-	5160	4940	3520	2530	12000	ND
Sodium	-	48900	29200	21600	15600	40100	ND
Vanadium	-	ND	ND	ND	ND	63.8	ND
Alpha-Benzene Hexachloride	-	0.009 U	0.004 U	ND	ND	0.003 C	0.008 U
DDT	-	0.012 C	ND	ND	ND	0.017 U	0.017 U
1,3-Dimethylbenzene	-	1.8	ND	ND	ND	ND	ND
Acetone	-	52	52	ND	ND	ND	ND
Bis(2-ethylhexyl) phthalate	-	ND	ND	ND	ND	ND	ND
Phenol	-	ND	ND	ND	ND	13	ND
						5.5	ND

TABLE ES-1d (cont.) Summary of Constituents Present in the Groundwater at the Industrial Waste Lagoons above MCLs

PARAMETER	MCL UG/L	S003MW1052 9/2/92	S003FD1052 9/2/92	S003MW1053 11/24/91	S003MW1600 12/10/91	S003MW1600 9/2/92	S003MW6D00 8/21/92
Aluminum	50-200	3840	9150	143	2390	262	57600
Beryllium	4	ND	ND	ND	ND	ND	36.5
Boron	-	257	274	ND	ND	271	1930
Cadmium	5	147	291	ND	ND	ND	ND
Calcium	-	153000	180000	93900	131000	187000	*
Chromium	100	41.8	119	ND	ND	ND	273
Cobalt	-	ND	ND	ND	ND	ND	25.1
Iron	300	18600	47100	1820	19300	1570	111000
Lead	15	6.71	14.6	ND	9.32	ND	470
Magnesium	-	30800	32700	38200	35000	32400	750000
Manganese	50	1810	4000	42.3	377	141	17000
Nickel	100	39.7	79.6	ND	ND	ND	152
Potassium	-	3610	5350	4280	3080	4010	122000
Sodium	-	31200	31600	32900	19600	40800	*
Thallium	2	ND	ND	ND	196	ND	ND
Tin	-	ND	ND	ND	ND	ND	94.9
Vanadium	-	ND	ND	ND	ND	ND	523
Alpha-Endosulfan	-	ND	ND	ND	ND	ND	ND
1,3-Dimethylbenzene	-	ND	ND	ND	> 0.5	ND	ND
2,4-Dimethylphenol	-	ND	ND	ND	ND	ND	14
Acetone	-	ND	ND	ND	ND	ND	13
Benzene	5	ND	ND	ND	ND	ND	> 100
							33

TABLE ES-1d (cont.) Summary of Constituents Present in the Groundwater at the Industrial Waste Lagoons above MCLs

PARAMETER	MCL UG/L	S003MW3900 8/21/92	S003MW4000 8/20/92	S003FD4000 8/20/92	S003MW40D0 8/21/92	S003FD40D0 8/21/92
Aluminum	50-200	94800	656	746	2520	1620
Beryllium	4	36.5	ND	ND	ND	ND
Boron	-	2420	557	393	1110	1180
Calcium	-	*	115000	93200	131000	115000
Chromium	100	210	ND	ND	ND	ND
Cobalt	-	69	ND	ND	ND	ND
Iron	300	186000	1680	1260	4080	2560
Lead	15	180	ND	ND	ND	ND
Magnesium	-	830000	37500	26900	43000	46800
Manganese	50	14000	157	142	292	201
Nickel	100	169	ND	ND	ND	ND
Potassium	-	125000	5680	5410	10900	12000
Sodium	-	*	48900	57800	190000	220000
Tin	-	102	ND	ND	ND	ND
Vanadium	-	523	ND	ND	ND	ND
1,3-Dimethylbenzene	-	1.6	ND	ND	ND	ND
Acetone	-	> 100	ND	ND	ND	ND
Carbon Disulfide	-	ND	ND	ND	5.6 R	ND

Key:

All results are in ug/l

ND - Not Detected

\* - This concentration for sodium is > 48900 ug/l

TABLE ES – 1e Summary of Constituents Present in Groundwater at Area B above Background						
PARAMETER	BACKGROUNDFACLMW0700UG/L	BACKGROUNDS2567MW070UG/L	BACKGROUNDAVERAGEUG/L	A00BMW112312/6/91	A00BMW11239/3/92	S2567MW45008/21/92
Aluminum	4520	3310	3915	6450	85100	171
Antimony	ND	ND	ND	73.2	ND	ND
Arsenic	ND	ND	ND	ND	10.9	ND
Barium	221	211	216	62.4	307	177
Beryllium	1.11	ND	0.555	ND	3.02	ND
Boron	ND	ND	ND	ND	305	278
Calcium	89300	82000	85650	182000	210000	ND
Chromium	ND	ND	ND	71	139	ND
Cobalt	ND	ND	ND	ND	35.9	ND
Copper	ND	100	50	ND	55.5	ND
Iron	4250	1900	3075	17600	84000	132
Lead	13.2	5.91	9.555	11.6	95.4	ND
Magnesium	28100	27500	27800	21000	40600	24200
Manganese	96.7	72.6	84.65	47.40	5120	53.2
Nickel	ND	ND	ND	ND	97.9	ND
Potassium	7080	5900	6490	4310	28000	8310
Vanadium	ND	ND	ND	ND	85.4	ND
Zinc	138	50.6	94.3	48.4	244	77

Key:  
All results are in ug/l  
ND – Not Detected



**TABLE ES-1f Summary of Constituents Present in the Groundwater at Area C above MCLs**

PARAMETER	MCL UG/L	A00CMW1009 12/5/91	A00CMW1009 9/2/92	
Aluminum	50-200 *	24300	15900	
Boron	-	ND	389	
Cadmium	5	ND	ND	
Calcium	-	80400	33600	
Iron	300	37800	16400	
Lead	15	25.1	19.9	
Magnesium	-	22700	15500	
Manganese	50	764	286	
Potassium	-	11800	6700	
Sodium	-	56000	94000	
Vanadium	-	42.2	ND	
1,3-Dimethylbenzene	-	ND	1.3	
Chloromethane	-	4.4	ND	

**Key:**

All results are in ug/l

ND - Not Detected

U - Unconfirmed Analysis

C - Confirmed Analysis

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## **1.0 INTRODUCTION**

This report presents the results and findings of a Phase 1 Groundwater Study performed in conjunction with a Phase 1 RCRA Facility Investigation (RFI) and Corrective Measures Study (CMS) performed during the period October 1991 through July 1994 at the Lexington-Bluegrass Army Depot (LBAD), located near Lexington, Kentucky. Performed for the United States Army Environmental Center (USAEC) under Task Order 4 of Contract DAAA15-90-D-0016, the Phase 1 Groundwater Report was one of the steps in a Phase 1 RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) program for the site. This program was performed in preparation for the site's closure under the Defense Authorization Amendments and Base Closure and Realignment Act of 1988. For convenience purposes, the Lexington-Bluegrass Army Depot Phase 1 RFI Final, dated August, 1995, will be referred to as the "RFI", while the Lexington-Bluegrass Army Depot Phase 1 Groundwater RFI/CMS Report will be referred to as the Groundwater Report or Groundwater Study.

The Lexington-Bluegrass Army Depot (LBAD), also identified as the Lexington Facility, is located on approximately 782 acres of land in Fayette and Bourbon Counties, about 10 miles east of Lexington, Kentucky (Figure 1.1). (Note: All figures and tables appear at the end of each section.) The area is primarily rural with some industry along the railroad which parallels the property's southern boundary.

The Lexington Facility began operation in 1941 as a signal depot. From 1941 to 1977 the installation's mission involved various paint stripping, metal plating, etching, and anodizing operations. In December 1988, the Defense Secretary Report on Base Realignment and Closure (BRAC) recommended the closure of LBAD.

### **1.1 PURPOSE OF THE REPORT**

The purpose of the investigation was to evaluate the nature, source, and extent of any contamination found in ground water, to assess contaminant migration pathways, and to identify potential receptors at risk from contaminated media and associated exposure pathways, as well as identify and evaluate remedial action alternatives which will provide for the containment, removal, and/or direct treatment of ground water at LBAD.

This report presents information and findings only for ground water and those media expected to affect ground water (soil, sediment, and surface water). The groundwater investigation was extended to include Phase II and Phase III field investigation data.

This report describes the procedures used to conduct the Groundwater Study, to assess the results of the study, and to recommend further actions, if necessary.

## **1.2 SITE LOCATION AND FACILITY DESCRIPTION**

The Lexington-Bluegrass Army Depot (LBAD) is located in Fayette County, Kentucky, in the town of Avon, approximately 10 miles east of Lexington (Figure 1.1). The Depot encompasses 782 acres which were acquired through the purchase of seven tracts of farm land. Figure 1.2 is a site map for the facility. LBAD is located within the Central Bluegrass Geological Region and is characterized by gently rolling hills dissected by numerous streams.

According to the 1988 Comprehensive Plan covering land use in Lexington-Fayette County, the facility property is divided between light industrial and general rural uses. The surrounding area is primarily rural, with some industry along the railroad tracks which run parallel to the southwestern boundary of the property. This industrial property belongs to the Prestress Concrete Co., which manufactures concrete construction beams.

## **1.3 SITE HISTORY AND BACKGROUND INFORMATION**

### **1.3.1 Site History**

The Lexington Facility was established as a signal depot authorized by Department of War General Order No. 6, dated June 25, 1941. The Depot was constructed in 1941-1942 for the storage of ground radar, other classified radio equipment, and special vehicles required to transport radar. During World War II, the Lexington Supply School and the Army's Electronics Power School were both housed on the Lexington Depot.

By 1945, the administration building, eight warehouses, the motor pool building, the power plant, and 40 wood-framed, concrete-based temporary buildings had been constructed. Following World War II, additional facilities have been added as required by mission changes or expansion. An industrial

maintenance shop (Building 135) was built in 1953, and two more warehouses (Buildings 220 and 221) were added in 1954. In the late 1950s, seven housing units were constructed. Through the 1960s and 1970s, a total of ten (10) buildings were built, including an electronic and communications security equipment maintenance facility (Building 147) and seven warehouses (Buildings 149-154 and 90) (Building Technology, Inc., 1984).

Since the facility was established in 1941, it has come under the command of a number of authorities. Table 1.1 summarizes the various changes in activities throughout the Depot's history. The installation was put under the jurisdiction of the Army Material Command (AMC) in June, 1966. In 1977, the Depot underwent a change in mission and function, was assigned as a depot activity, and placed under the command of Red River Army Depot, Texas. Command was transferred to Anniston Army Depot, Alabama, in July, 1980. In September, 1986, due to its size and the variety and sensitivity of its missions, the Lexington Facility was placed under the command of the Lexington-Bluegrass Army Depot, Lexington, Kentucky. It is one of 13 depots under the Depot System Command, Chambersburg, Pennsylvania.

### **1.3.2 LBAD RFI/CMS Report**

The RFI field investigation was conducted in two phases. Phase 1 was performed during the period October 1991 to December 1991. After review of the results of the Phase 1 investigation, additional sampling was recommended for some areas previously sampled and for additional areas. This additional sampling was identified as Phase II activities. Phase II activities were performed from July 1992 to February 1993. It was determined from the Phase II data evaluation that the ground water from monitoring well MW-18 and MW-32 contained vinyl chloride; therefore, a Phase III investigation was planned. In order to proceed with the RFI/CMS, it was agreed by USAEC, KDEP, and U.S. EPA that groundwater contamination would be broken out as a separate Operable Unit (a CERCLA term agreed upon for this site). Therefore, the RFI was issued as a Final Document in April 1994, and the CMS was issued as a Draft Final in June 1994. The Phase III investigation consisted of the installation and sampling of four monitoring wells, two shallow and two deep; a pumping test; a soil gas survey; and a dye trace test.

## **1.4 REPORT ORGANIZATION**

The organization of the Lexington Groundwater RFI/CMS was reviewed by the State and Federal regulatory agencies as an annotated outline. Based on the review, the report is organized into twelve sections. Section 1 is an introduction to the groundwater report. It consists of an explanation of the purpose of the study, a description of the facility, a brief overview of site history, and a description of the RFI/CMS report and the need for the Groundwater Report.

Section 2 describes the Groundwater Investigation Activities. These include a description of procedures used for drilling, logging, sampling, and constructing subsurface soil borings, subsurface bedrock sampling, soil gas sampling, monitoring well installation and sampling, well development, water level measurements, surveying, and aquifer characterization. Aquifer characterization consists of slug tests, pumping test, and dye trace testing.

Section 3 describes the physical characteristics of the study area. A description of the regional geology is followed by a description of site geology. The discussion of ground water on-site includes groundwater occurrence, flow directions and hydraulic gradient, aquifer characteristics, and groundwater velocity.

Section 4 describes the processes used to ensure quality assurance/quality control. This consists of a description of the quality assurance program, a quality control measures overview, a description of the analytical services, data quality assessment, and data management.

Section 5 is a description of the nature and extent of contamination on-site. This involves a discussion of field investigation results, potential contamination sources, and contamination fate and transport.

Section 6 describes the risk assessment for human health. This section involves an introduction, a description of the selection of chemicals of potential concern, exposure assessment, toxicity assessment, risk characterization, uncertainties in the baseline risk assessment, and a summary and conclusions of the risk assessment findings, with particular emphasis on the risk characterization.

Section 7 contains a summary and conclusion of the RFI portion of the groundwater RFI/CMS. This section will summarize findings and determinations and will summarize the rationale used to determine which areas will be covered in the CMS portion of the groundwater RFI/CMS.



Section 8 is a description of the CMS, the approach used in development of the CMS, and background information pertinent to the CMS.

Section 9 consists of the identification and screening of technologies. This section will consist of an introduction to discuss the approach used to identify and screen remedial technologies and process options as well as a description of remedial action objectives, identification of general response actions, estimation of areal extent and volume of contamination, and identification and initial screening of treatment technologies/remedial actions.

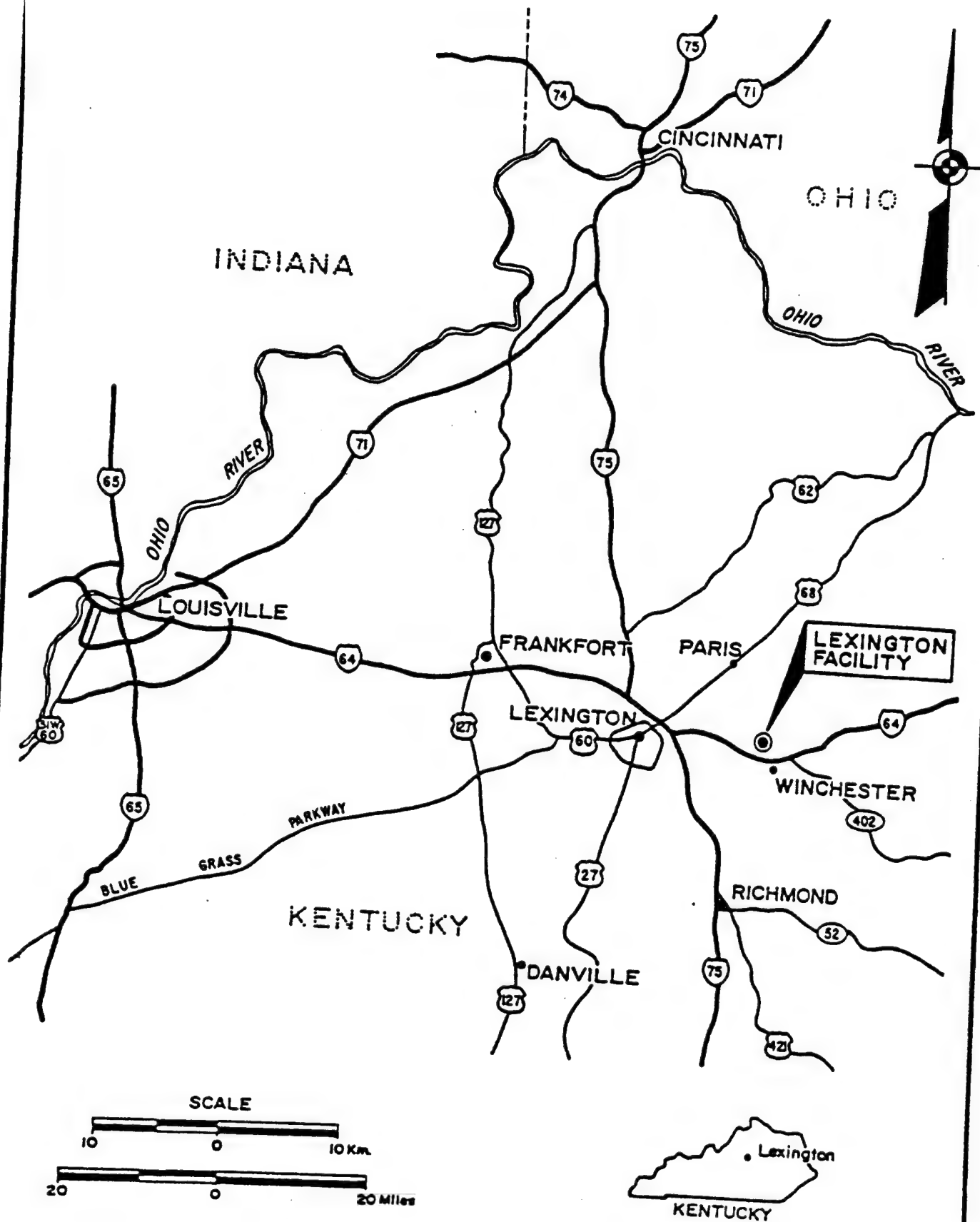
Section 10 describes the development and screening of alternatives. This section will consist of an introduction to describe the approach taken to develop, evaluate and screen remedial alternatives, a description of the screening of treatment options, and a description of development and screening of alternatives.

Section 11 describes the detailed analysis of alternatives. This consists of an introduction which will present a brief summary of the approach used to analyze and evaluate the alternatives, a section describing the alternatives analysis, and a comparative analysis of alternatives.

Section 12 is the reference section.

**TABLE 1-1**  
**SUMMARY OF HISTORY OF THE LEXINGTON FACILITY**

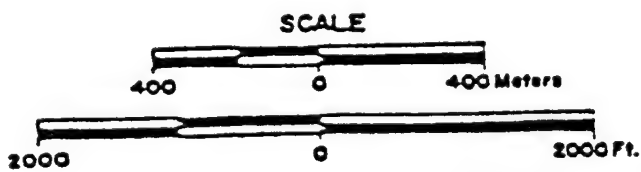
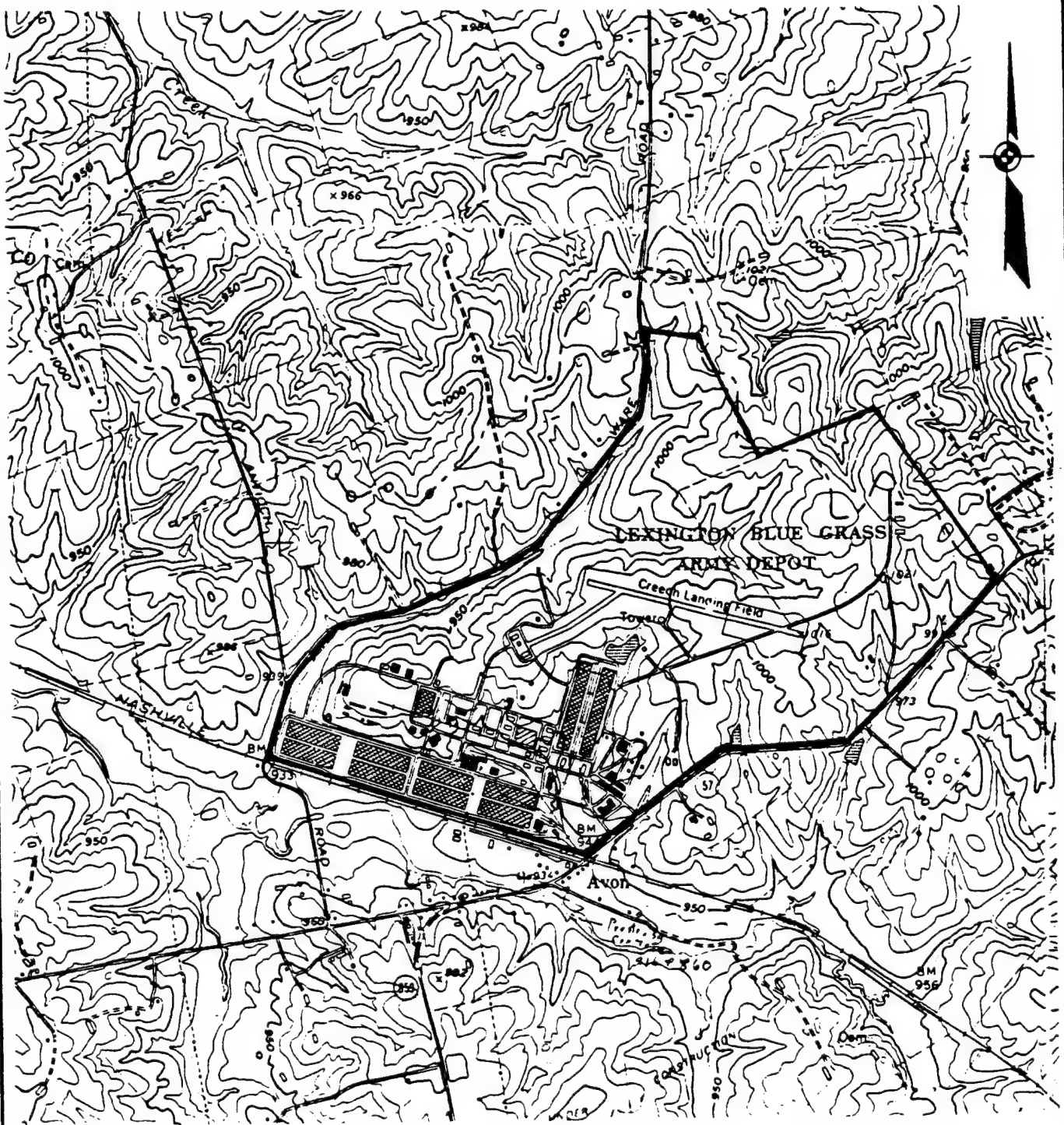
<b>DATE</b>	<b>SIGNIFICANT EVENT</b>
25 June, 1941	Installation is established by the Department of War General Order No. 6.
1 July, 1941	Construction begins
1952	The Depot is responsible for overseas signal support through the New York and New Orleans ports.
1961	The Decatur, Illinois Signal Depot (which had assumed the New Orleans support) is deactivated and most of that mission is transferred to Lexington.
1 August, 1962	The Depot is redesignated as the Lexington-Bluegrass Army Depot, and placed under the command of the US Army Supply and Maintenance Command, Department of the Army.
27 August, 1964	Department of the Army General Order No. 29 establishes the Lexington-Bluegrass Army Depot as a Class II installation under the command of the Commanding General, US Army Supply and Maintenance Command.
6 June, 1966	AMC General Order No. 28 places the Lexington-Bluegrass Army Depot (Lexington Facility) under the jurisdiction of the Army Materiel Command.
4 July, 1977	The Lexington Facility assigned as an activity under the command of the Red River Army Depot, Texas; change in mission and function.
July, 1980	The Lexington Facility is placed under the command of Anniston Army Depot, Alabama.
September, 1986	The Lexington Facility is placed under Lexington-Bluegrass Army Depot.
December, 1988	The Lexington Facility is identified for closure.



LEXINGTON-BLUEGRASS ARMY DEPOT  
**LOCATION MAP**  
LEXINGTON, KENTUCKY

Project Number  
007248

Figure  
1.1



**M&E**  
Metcalf & Eddy

LEXINGTON-BLUEGRASS ARMY DEPOT  
SITE MAP  
LEXINGTON, KENTUCKY

Project number  
007248  
Figure  
1.2

## **2.0 GROUNDWATER INVESTIGATION ACTIVITIES**

The following sections of this report summarize field activities associated with each media investigated which pertains to the Ground Water Study.

### **2.1 SUBSURFACE SOIL BORINGS**

Soil investigations conducted at the Lexington-Bluegrass Army Depot (LBAD) consisted of the drilling and logging of 104 soil borings to various depths. The soil borings were drilled according to the procedure described below. These borings were logged using a 2-inch I.D. split-barrel sampler. The boring locations can be found on Figure 2-1, and the boring logs can be found in Appendix A. All samples were analyzed for TCL and TAL analytes listed in Tables 4.2 through 4.6.

#### **Equipment:**

- Diedrich D-50 rotary drill rig
- 6-inch I.D. hollow-stem auger
- 2-inch ID x 24-inch long split-spoon sampler
- Pre-labeled sample jars
- Stainless steel spoon
- Stainless steel bowl

#### **Procedure:**

At the ground surface and at each specified interval, a split-spoon sampler was driven 24 inches by a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler in 6-inch increments was recorded. After driving the sampler 24 inches, it was removed from the borehole, opened, and the contents screened for total volatile organics using a Photo Ionization Detector (PID) and/or Organic Vapor Analyzer (OVA). Any observed deflections on the instruments were recorded on the boring log. During all drilling operations, the air breathing zone was continuously monitored with the PID and OVA to ensure worker safety. The soil in each split spoon was described in the field by a qualified geologist using a Munsell Soil Color Chart and the Unified Soil Classification System (USCS); observations were recorded on the soil boring logs.

At specific intervals, up to three discrete samples were collected for chemical analysis based on the requirements of the work plan. Using a stainless steel spatula, or spoon, an aliquot from the sampler was transferred to a 4-ounce sample jar for analysis of VOCs. The remaining soil in the sampler was transferred to a stainless steel bowl and homogenized. Once the sample was completely mixed, the remaining sample bottles were filled and all sample bottles were labeled, sealed, placed in plastic bags, packed in a cooler with ice, and cooled to 4°C.

Upon completion, the boring was grouted from the bottom upward to ground surface using a PVC tremie pipe. The grout consisted of batch mixtures of 94 pounds of Portland Type II cement, 8 gallons of tap water, and 5 pounds of powdered bentonite. All grout was mechanically mixed using a grout mixer. Backfilled borings were revisited after 24 hours, and additional grout was placed if settlement had occurred.

The geologic logs containing all pertinent observations and drilling information can be found in Appendix A.

## **2.2 SUBSURFACE BEDROCK SAMPLING**

Four lithologic borings were completed using a 1 7/8-inch rock-core barrel and water-rotary drilling as described below. One core boring was completed at each of four on-site areas. A core was collected and logged at the Industrial and Sanitary Waste Landfill (Core No. 2), the New Landfill (Core No. 1), the Old Landfill (Core No. 3), and the Waste Lagoons (Core No. 4) to a depth of 100.5 feet, 185.2 feet, 106.8 feet, and 133.6 feet, respectively. Core locations can be found on Figure 2-2. Core logs and photos can be found in Appendix B.

### Equipment:

- CME-55 rotary drill rig
- 6-inch ID hollow-stem augers
- 2-inch ID x 24-inch long split-spoon sampler
- 1 7/8-inch NX core barrel
- Wire-line core-barrel retrieval system

### Procedure:

Each boring was advanced to bedrock using a 6-inch ID hollow-stem auger (HSA). The boring was sampled continuously using a 2-inch ID by 24-inch long split-spoon sampler. Each sample was described and logged in the core boring log.

Upon reaching bedrock, the HSA was pulled and a 6-inch ID PVC casing was installed in the boring. The annulus between the boring and the casing was temporarily sealed using bentonite powder and clean water.

The boring was then advanced to total depth using water rotary drilling with a 1-7/8-inch NX core barrel on a wire-line retrieval system. As the boring was advanced, penetration rate and water loss were noted.

As the rock core was retrieved, it was placed in core boxes. Core loss was noted using annotated wooden blocks. Each rock core was cleaned, wetted, and recovery, lithology, core loss, fracture geometry, and Rock Quality Designation (RQD) were logged. Core boxes were marked inside and out with the boring number, cored interval, and box number. Each box was then photographed wet. Boring logs and photographs are given in Appendix B.

Upon completion of the boring, all tools were retrieved. The PVC temporary casing was pulled from the hole and the boring was abandoned by grouting to the ground surface in accordance with USATHAMA procedures as given in USATHAMA Geotechnical requirements.

All project waste generated as a result of rock coring activities was disposed according to the procedure outlined in the Lexington-Bluegrass Army Depot RCRA Facility Investigation Final Report dated March 1995.

## **2.3 SOIL GAS SAMPLING**

The soil gas sampling at LBAD was conducted in three phases. Both Phase 1 and Phase 2 were discussed in detail in the Lexington-Bluegrass Army Depot, Final Report, RCRA Facility Investigation, April, 1994. These two phases consisted of an initial, limited soil-gas survey conducted by M&E to determine if there was soil-gas contamination along the immediate perimeter of identified buildings, the landing field, and the open storage area. The results of this survey were then used to identify areas requiring a



second, more extensive soil-gas survey which was conducted by Target Environmental Services Inc. to further delineate potential contamination identified during the initial survey.

Phase 3 soil-gas sampling was used as a screening tool to locate or confirm the suspected source of vinyl chloride contamination found in wells MW-18 and MW-32. The survey was centered around well MW-32 and trended toward the Industrial and Sanitary Waste Landfill (ISWL), the Fire Training Area, and the DRMO. Samples were initially collected on a 100 foot grid. This sample pattern was reduced to 50 feet and ultimately 25 feet around the areas where positive analytical results were detected. A total of 287 soil-gas samples were collected from depths ranging from one to four feet. The majority of the samples were collected from the 4 foot depth. Samples collected at a depth less than 4 feet were the result of probe refusal. Figure 2-3 is a copy of the Phase 3 soil-gas field map which shows sample locations and corresponding sample numbers.

To collect the samples, a 1/2-inch-diameter hole was produced by driving a rod to a depth of approximately 4 feet. Where pavement was present, a rotary hammer was employed for penetration prior to using the drive rod. The entire sampling system was purged with ambient air drawn through an organic vapor filter cartridge, and a hollow stainless steel probe was inserted to the full depth of the hole and sealed off from the atmosphere with bentonite. A sample of in-situ soil gas was then withdrawn through the probe and used to purge atmospheric air from the sampling system. A second sample of soil gas was withdrawn through the probe and encapsulated in a pre-evacuated glass vial at two atmospheres of pressure (15 psig). The self-sealing vial was detached from the sampling system, packaged, labeled, and stored for laboratory analysis. All sampling holes were backfilled with bentonite and the surface repaired with like material upon completion of the sampling.

Prior to each day's field activities all sampling equipment, slide hammer rods and probes were decontaminated by washing with soapy water and rinsing thoroughly. Internal surfaces were flushed dry using pre-purified nitrogen or filtered ambient air, and external surfaces were wiped clean using clean paper towels.

All of the samples collected during the Phase 3 soil-gas survey were analyzed by Maryland Spectral Services, Inc. (MSS) according to EPA Method 624, modified for vapor analysis on a gas chromatograph equipped with a mass spectrometer. Vinyl chloride was standardized for this analysis.

The results of the laboratory analysis of the soil gas samples are reported in micrograms per liter ( $\mu\text{g}/\text{l}$ ) and are included in Appendix C, Soil Gas Data, Lexington Bluegrass Army Depot, Lexington, Kentucky, Target Environmental Services, Inc., August, 1993.

Of the 287 soil gas samples collected, only 7 had vinyl chloride concentrations greater than the detection limit of  $0.5 \mu\text{g}/\text{l}$  air. Sample numbers 9, 144, 160, 224, 228, 244, and 282 had concentrations of  $2.1 \mu\text{g}/\text{l}$  air,  $0.5 \mu\text{g}/\text{l}$  air,  $0.9 \mu\text{g}/\text{l}$  air,  $0.5 \mu\text{g}/\text{l}$  air,  $2.6 \mu\text{g}/\text{l}$  air,  $1.0 \mu\text{g}/\text{l}$  air and  $0.5 \mu\text{g}/\text{l}$  air, respectively. It should be noted that all 7 samples which tested positive for vinyl chloride were collected within the boundaries of the ISWL. As shown on Figure 2-3, three areas of positive vinyl chloride concentration can be distinguished, separated by a distance of 100 feet or more. These areas are designated as Areas A, B, and C on Figure 2-3. The highest vinyl chloride concentrations occur within Area B at  $2.6 \mu\text{g}/\text{l}$  air, and Area C at  $2.1 \mu\text{g}/\text{l}$  air.

Although the horizontal extent of vinyl chloride contamination within the soil gas is small, and the concentrations are low, they are upgradient of MW-18 and MW-32 and confirm the ISWL as the suspected source of vinyl chloride contamination within the ground water at these wells.

## **2.4 MONITORING WELL INSTALLATION AND SAMPLING**

A phased approach was used to install a total of thirty-nine monitoring wells and four piezometers at the Lexington-Bluegrass Army Depot. Eleven monitoring wells were installed during November 1991. The data gained during the installation and sampling of these wells were then used to locate and install an additional twenty-eight wells: Well MW-19 was installed in May 1992 and the remaining twenty-three monitoring wells were installed during July and August 1992. Data from these wells was then used to locate and install 4 more wells during September, 1993. The date of installation of each well can be found in Table 2-1. All wells were installed according to the procedure described in Section 2.4.2. Wells installed during November 1991; May, June and July, 1992; and September of 1993 are referred to as Phase I, II, and III wells, respectively.

Twenty-five of the 39 monitoring wells were installed as shallow wells. Twelve wells were set as deep wells paired with shallow wells. Two wells were installed as interface wells. The location of all wells are shown on Figure 2-4. Well number, elevation, first water elevation, and total depth are shown in Table 2-1. Well construction diagrams are located in Appendix D.

All project waste generated as a result of well installation and sampling was disposed according to the procedure outlined in the Lexington-Bluegrass Army Report RCRA Facility Investigation Final Report dated March 1995.

#### **2.4.1 Monitoring Well and Piezometer Drilling**

The monitoring wells installed by Metcalf & Eddy at LBAD were drilled using a phased approach; therefore, changes were made in the installation procedure for Phase II and Phase III wells based on stratigraphic information learned during the Phase I investigation. The changes were made in order to better facilitate well installation and maximize data collection.

Monitoring well numbers MW-1 through MW-18 were installed during Phase I field work as follows:

Each well boring was advanced to bedrock using a 6 1/4 I.D. hollow-stem auger (HSA) and was sampled continuously using a 2-inch ID split-barrel sampler. Each sample was described and logged by a qualified geologist using a Munsell Color Chart, the Unified Soil Classification System (USCS) and the USATHAMA Geotechnical Requirements for Drilling, Monitoring Wells, Data Acquisition, and Reports. The geologic logs and well construction logs containing all pertinent drilling information can be found in Appendices D and E.

Upon encountering bedrock, the 6 1/4-inch HSA was removed. The boring was then over-drilled using a 12-inch O.D. auger to bedrock. The 12-inch O.D. auger was removed and a 10-inch I.D. PVC casing was installed into the boring and grouted into place. The grout seal was allowed to cure for at least 8 hours before drilling was continued.

Drilling was continued through the 10-inch PVC Casing to total depth using an air rotary rig equipped with an 8-inch tricone bit.

When it was determined that water had been encountered, the drilling tools were pulled to allow the water to enter the boring. After waiting approximately 20 to 30 minutes, the well was installed.

The procedures used to drill Phase II and Phase III wells (MW-19 through MW-48) and piezometers (P1 through P4) were the same as Phase I wells with one exception. The 10-inch surface casings which were

installed at the top of bedrock during installation of the Phase I wells were deleted on Phase II and Phase III wells.

A total of thirty-nine borings were drilled and completed as wells. An additional twenty borings were drilled, but not completed as wells because no water was encountered. All wells were split-spoon sampled to bedrock and drilled to depth using an 8-inch tricone bit and an air-rotary rig. Therefore, all borings were logged to bedrock using split-spoon samples and were logged from bedrock contact to total depth using drill cuttings. Well boring logs for installed wells, piezometers, and dry holes can be found in Appendix E and F, respectively. The total depths of completed wells and piezometers are listed in Table 2-1. The locations of completed wells are shown on Figure 2-4. The total depths of the dry holes are shown in Table 2-2.

## **2.4.2 Monitoring Well and Piezometer Construction**

### **2.4.2.1 Shallow Wells and Rock Interface Wells**

Upon encountering water during drilling, the drilling tools were pulled to allow water to enter the boring. The boring was allowed to stand for 20 to 30 minutes. The water level was then checked to determine if it had risen above the level where it was first encountered, or remained at the original level. If the water remained at the level where first encountered, a 15-foot screened ground water interface well was to be installed. If the water had risen in the well, a 10-foot screen was to be installed at the depth water was first encountered. Water rose in all shallow wells drilled; therefore, all shallow wells were installed using a 10-foot screen. All shallow wells were constructed of 4-inch I.D. Schedule 40, PVC casing and screen with 10 feet of 0.01-inch slot size screen. All casing and screen joints were flush-jointed. Filter pack consisted of 20-40 Colorado Silica sand. Bentonite seals consisted of 1.4 inch calcium bentonite pellets. All shallow wells were grouted to the surface with batch mixture of grout consisting of 94 pounds of Portland cement, three pounds of calcium bentonite powder, and 7.5 gallons of water.

Each shallow well was constructed with the screened interval at the point where water was first encountered. A sand filter pack was installed which extended approximately 5 feet above the top of the well screen. A bentonite seal was placed to approximately 5 feet above the top of the sand pack and allowed to hydrate at least 2 hours. After the bentonite seal had hydrated, the well was grouted to the surface using a tremie pipe, and a steel protective casing with locking cap was installed in the boring over the well casing. After the grout had cured for at least 24 hours, a 0.5 foot-thick gravel well apron was

placed around the protective casing radially to 4 feet, and 4 steel guard posts were installed, one at each corner of the gravel well apron.

Due to the lack of a shallow aquifer at the northeast side of the base, shallow wells were not installed. In order to monitor any discharge from the eastern side of the New Landfill, two bedrock interface wells were installed. Bedrock interface well locations can be found on Figure 2-4. The two bedrock interface wells (MW-43I and MW-44I) were both installed using the same well materials (i.e., 4-inch Schedule 40 PVC screen and casing, Colorado sand, etc.) as were used for the aforementioned shallow wells. The bedrock interface wells were constructed using a 10-foot screen at the bedrock soil interface, 1 foot of sand, 1 foot of bentonite pellets, and grout to the surface. As with the shallow wells, a protective casing, steel posts, and a gravel well apron were installed. These wells act essentially as sumps to collect any leachate from the New Landfill during top-of-rock flow.

#### 2.4.2.2 Deep Wells

It was decided that deep wells would be installed adjacent to shallow wells to aid in the determination of horizontal extent of contamination where it exists. The deep wells were constructed such that the top of the well screen was 20 feet below the bottom of the paired corresponding shallow well screen. With 5 feet of sand filter pack above the top of the well screen, only 15 feet of unscreened interval exists between the shallow wells and the corresponding deep wells.

All deep wells were drilled to predetermined total depth without regard to water encountered. Due to the interbedded nature of the site geology and the scarcity of water, 20-foot screens were used to increase the likelihood of encountering enough water to sample. All deep wells were constructed using the same well materials used to construct the shallow wells (i.e., Schedule 40 PVC, 0.01 slot screen, Colorado silica sand, etc.). Each well was constructed such that a sand filter pack was installed which extended approximately 5 feet above the top of the well screen. A bentonite seal was placed to approximately 5 feet above the top of the sand pack and allowed to hydrate at least 2 hours. After bentonite seal hydration, the annulus was grouted to the surface using a tremie pipe, and a steel protective casing with locking cap was installed in the boring over the well casing. After the grout was allowed to set for at least 24 hours, a 0.5 foot-thick gravel well apron was placed around the protective casing radially to 4 feet, and 4 steel guard posts were installed on each corner of the gravel apron.

#### 2.4.2.3 Piezometers

Four piezometers were installed around well MW-32 to be used in conjunction with the pumping test conducted in September, 1993. Each piezometer was drilled using a 6 3/4-inch tricone bit and air rotary drilling technique. Upon encountering ground water, the boring was drilled to 10 feet below first water. A 10-foot-long 2-inch I.D., 0.01 slot schedule 40 PVC screen and riser was installed. A sand filter pack of 20-40 Colorado silica sand was installed to five feet above the top of the piezometer screen. A bentonite seal of 1/4-inch bentonite pellets was then placed to approximately 5 feet above the top of the sand pack and allowed to hydrate a least 2 hours. After the bentonite seal had hydrated, the piezometers were grounded to the surface using a tremie pipe and a steel protective casing with a locking cap was installed in the boring over the well casing. After the grout was allowed to set for at least 24 hours, a 0.5 foot-thick gravel well apron was placed around the protective casing radially to 4 feet, and 4 steel guard posts were installed, at each corner of the gravel well apron.

#### 2.4.3 Well Development

##### Equipment:

- pH meter
- Conductivity meter
- Temperature probe
- Water level indicator
- 1.5-inch OD stainless steel bailer or pump (with appropriate length of hose)
- Rope (new braided nylon)
- Sample jar(s)

##### Initial Air Monitoring

Well development began a minimum of 48 hours after well installation was complete. Upon arrival at each well, the head space in the well and the ambient air in the breathing zone were monitored for hazardous constituents using an Organic Vapor Analyzer (OVA) and/or a Photo Ionization Detector (PID). All readings were recorded in a Metcalf & Eddy field logbook and/or on the development log sheets found in Appendix G.

## Volume Calculation

The static water level was measured using a decontaminated water level indicator. This water level was then compared to the static water level from the well construction diagram to determine if any changes had occurred. The depth, in feet, of standing water in the well was determined by subtracting the static water level from the well depth, both measured from the same point. Calculation of well volume was determined by using a volume calculation diagram (Figure 2-5). This diagram included the volume of water in the 4-inch ID well, as well as the annular space and the sand pack porosity. The minimum volume purged was five well volumes, plus any water added during installation to hydrate the bentonite. An appropriate number of 55-gallon drums on pallets were placed next to the well for storage of development water.

## Development Equipment

Depending on the depth to water and the recharge rate, a decontaminated stainless steel bailer or a decontaminated submersible pump was used for development. If a bailer was chosen, new braided nylon rope was attached to the top of the bailer and the bailer was lowered to the bottom of the well. Sufficient time was allowed for the bailer to fill, then it was pulled up out of the well and emptied. The nylon rope was never allowed to contact the ground surrounding the well. This process was repeated until the development-volume requirements were met. If the submersible pump was used, decontaminated hose was attached to the discharge fitting using stainless steel clamps. New braided nylon rope was attached to the top of the pump to secure it at the desired depth in the well, usually 18 inches from the bottom. The development water was discharged into a 55-gallon drum.

Purging rates varied, depending on the equipment used. The submersible pump removed water at rates as high as 20 gpm; bailing averaged 0.5 gpm.

## Development Procedure

During development, samples of well water were collected to monitor changes in quality and appearance. An initial sample was collected after 0.5 to 1.0 gallons had been purged, and additional samples were collected after every well volume, if recharge permitted. Glass jars were triple-rinsed with the well water before each sample was collected. The pH, conductivity, and temperature were measured and recorded on the well development forms (located in Appendix G), along with the time, turbidity, appearance,



volume bailed or pumped, and rate of bailing or pumping. The volume of water bailed or pumped was measured with a calibrated 5-gallon bucket. The water was then transferred to a 55-gallon drum. Bailing or pumping rates were measured for each 5-gallon bucket. The breathing zone was monitored for volatile organic vapors throughout development using an OVA or PID.

Development continued until the following three criteria were met:

1. Well water was cleared of all silts, clays, or sand.
2. pH, conductivity, and temperature had stabilized to within 10%.
3. A minimum of five well volumes had been removed.

After five well volumes had been removed, a sample was taken to determine if the water was clear and if the parameters in Item 2 had stabilized. If these criteria were not met, then purging continued until parameters in Items 1 and 2 were met. An average of 77 gallons of water were removed during well development. Out of 47 wells, 12 (26%) recharged slowly, to the point where the well became dry. When this occurred, development was temporarily stopped and the water level was monitored over the next 2 to 4 hours to determine a gross rate of recharge. After the well had recharged, it was pumped or bailed dry two more times and was considered developed.

At the end of development, all 55-gallon drums containing development water were labelled with contents, well number, and date, and were then secured with a lid. A final static water level in each developed well was measured to determine a gross rate of recharge.

A summary of well development data is presented in Table 2.3.

Table 2-3 shows the well number, date installed, amount of water required to purge for development, and volume of water purged.

All project waste generated as a result of well development was disposed according to the procedure outlined in the Lexington-Bluegrass Army Depot RCRA Facility Investigation Final Report Dated March 1995.

It should be noted that the required purge-water volume could be extracted from almost all the shallow wells without much difficulty, indicating a highly transmissive zone in the screened interval. The

exceptions to this were MW-22, MW-43I, and MW-44I. All three wells are located in the New Landfill area. MW-43I and MW-44I are interface wells which screen the bedrock-soil interface. Therefore, these wells would be expected to contain water only at times of high precipitation. Well MW-22 was drilled and produced considerable water, but dried up during development. It is believed that a pocket of water was intercepted during drilling, was drained during development, and will not recharge until a precipitation event occurs, similar to an interface well.

It should be noted that difficulty was experienced developing all deep wells with the exception of MW-40D, MW-47D, and MW-08D, which are located on the southern boundary of the facility or along the tributary at the western boundary of LBAD. This would lend credence to the concept that the zone beneath the shallow wells has a relatively low transmissivity, and the bottom of the "aquifer" or fractured zone was screened. It should be noted that wells with very low production rates were not sampled.

#### **2.4.4 Monitoring Well Sampling**

Thirty-nine monitoring wells were installed at the Lexington-Bluegrass Army Depot (LBAD) between November, 1991 and September, 1993. These wells were installed according to the procedures described in Section 2.4.2.

Eleven of the monitoring wells, MW-01, MW-02, MW-03, MW-04, MW-05, MW-06, MW-07, MW-08, MW-09, MW-16, and MW-18 were installed during Phase I of the RFI. Ten of these wells, along with the eight previously existing wells, were sampled during November and December of 1991. MW-01 did not have enough water to sample due to a plugged screen. This well was subsequently abandoned.

The monitoring well MW-19 was installed and sampled in May of 1992.

The twenty-three monitoring wells, MW-19DD, MW-22, MW-22D, MW-23, MW-23D, MW-32, MW-32D, MW-33, MW-35, MW-39, MW-40, MW-40D, MW-41, MW-42, MW-18D, MW-02D, MW-06D, MW-43I, MW-44I, MW-46, MW-45, MW-47 and MW-08D, were installed during July and August 1992. These wells were then sampled in August and September of 1992. At the same time, six wells, MW-1051, MW-1052, MW-16, MW-1123, MW-1009, and MW-04, sampled during Phase I, were resampled. Well numbers MW-1051, MW-1052, MW-1123, and MW-1009 were existing wells installed prior to the Phase I field work of this RFI. Results of analyses from Phase I showed that several analytes

exceeded the Maximum Contaminant Levels (MCLs). Therefore, confirmatory samples of the indicated wells were taken during Phase II.

Upon analysis of Phase 2 samples, it was determined that well number MW-32 contained vinyl chloride contamination. Therefore, well numbers MW-47B and MW-47BD, MW-48, and MW-48D were installed and sampled during September, 1993.

Groundwater sampling consisted of two stages: pre-sample purging, and sampling. The methods used for each stage are discussed below.

#### Equipment:

- Two-inch Grundfos® submersible pump
- Gas powered generator
- Braided nylon rope (new for each sampling event)
- Water-level indicator
- Stainless-steel bailer
- pH meter
- Conductivity meter
- Thermometer (digital or stainless-steel probe type)

#### Procedures:

All equipment was decontaminated prior to purging. The well pad was covered with plastic and the pump assembly set up as much as possible prior to the well being opened. When the well was opened, the head space and breathing zone were checked with an HNu or OVA, or both. The depth of water in the well was determined by measuring the depth to water and subtracting that from the total depth of the well. Calculation of well volume was determined by using a volume calculation diagram (Figure 2-5). This volume included water standing inside the well plus the annular space of the sand pack. A total of five well volumes were needed to be purged from each well. The amount of water purged from each well is shown in Table 2-3.

Purging was typically accomplished with a submersible pump operated by a gasoline-powered generator. The volume of water purged was measured using a five-gallon bucket. The purge water was stored on-site in 55-gallon drums as described for well development. After each well volume was purged, the temperature, pH, and conductivity of the purge water were measured and recorded on the well sampling

sheets. At the conclusion of purging, the pump was removed, and the well locked until sampling, which was performed within 2 hours after purging.

Not all monitoring wells had recharge rates that permitted pumping or purging all five well volumes (Table 2-3). These wells were purged using a stainless-steel bailer. They were bailed dry, then allowed to recharge to greater than 80 percent recovery (generally 1 hour or more). The volume bailed was recorded on the well sampling sheets, and the temperature, pH, and conductivity of the purge water were recorded at the end of each purge volume. Wells that had slow recoveries were bailed dry three times before sampling.

A total of eight previously existing monitoring wells were also sampled. There were no construction records available for these wells. The total depth of each well was measured using a water level meter indicator. It was assumed that the wells were installed using the same bore-hole size as the wells installed by M&E. The purge volume was then determined by using the volume calculation diagram.

Groundwater samples were collected as follows: Samples were obtained from each monitoring well within 2 hours of purging. Samples were collected with a stainless-steel bailer lowered on the same nylon rope used for the purging pump. The rope was discarded after use at each well. Prior to sampling, two full bailers of ground water were purged from the well. The pH, conductivity, and temperature were then measured.

All of the bottles to be filled during sampling were triple rinsed with water purged from the well, with the exception of the VOC vials which were not rinsed. Three 40-ml vials, two 1-liter amber glass bottles, one 1-liter polyethylene bottle, and one 500-ml polyethylene bottle (7 bottles) were rinsed for each sample. The 40-ml vials for VOC analysis were filled first. If water was left in the bailer after the vials were filled, the water was used to fill one of the amber glass bottles, starting with the one for semi-VOCs, then progressing to the pesticide/PCB bottles.

Vials for VOC samples were preserved with concentrated hydrochloric acid (HCl), either prior to or during filling of the vial. The HCl was placed into the vial using a new glass pipette dropper for each set of vials at each well. The amount of HCl placed in each vial was determined by filling a test vial, then adding five drops of HCl and testing to be sure the pH was less than two. The test vial was then discarded. After sampling approximately one-half of the wells, this step was dropped, and five drops were used as a standard, unless the pH of the water was greater than seven or less than four. Once the

vial was filled, preserved, and capped, it was checked to be sure no air bubbles were trapped inside. If air bubbles were present, the vial was emptied and refilled following the same procedure.

The sample collected in the 500-ml polyethylene bottle, for metals analysis, was preserved with a premeasured amount of  $\text{HNO}_3$  added after the bottles were rinsed. The sample collected in the 1-liter polyethylene bottle, for cyanide analysis, was preserved with a premeasured amount of  $\text{NaOH}$ . The bottles were pre-labeled and taped. The time and date were written on the label after the sample was taken. The samples were then sealed with chain-of-custody tape, placed in Ziploc™ bags, and stored on ice in a cooler until they could be taken to the office trailer. Duplicate samples were taken at some wells. For duplicate samples, a second full set of bottles was triple rinsed, preserved, and sampled as above. Discussion of field quality control samples is given in Section 4.5.

All project waste generated as a result of monitoring well sampling was disposed according to the procedure outlined in the Lexington-Bluegrass Army Depot RCRA Facility Investigation Final Report dated March 1995.

#### **2.4.5 Water Level Measurements**

Water-level measurements were collected prior to well development and prior to purging for sampling. These measurements were used to calculate the volume of water which had to be removed from each well to ensure proper development, or proper purging for sampling. These measurements were not considered to be representative of steady-state ground water conditions. Therefore, four other sets of water-level measurements were collected. The measurements for each set were collected on the same day, and were collected at least two weeks after the wells had been purged. This assured that all measurements would be representative of natural conditions. All wells installed prior to August 1992 (Phase I wells) were measured on January 10, 1992 and again on March 16, 1992. All wells including wells installed prior to and after August 1992 (Phase I and Phase II wells) were measured on September 21, 1992. All wells including Phase III wells were measured on December 9, 1993. Water level measurements for all three events are shown on Table 2-1. All measurements were made using an electronic water level tape to the nearest .001 foot.

#### **2.4.6 Survey**

A topographic survey was done on all boring and monitor wells at LBAD in order to fulfill the requirements of USATHAMA Geotechnical Requirements, March 1987. This survey included both horizontal and vertical control to accurately determine the coordinates of each installation.

Horizontal control was based on datum from the North American Datum of 1983 (NAD 83). Coordinates for the wells and borings were reported using the Universal Transverse Mercator (UTM) method. Tolerances were found to be within the  $\pm 3.0$  foot requirement.

Vertical control was established from brass tablet benchmarks located near the LBAD facility. Elevations of the benchmarks are based on the National Geodetic Survey Datum of 1929, the most recent general adjustment of benchmarks. Mean sea level elevations were determined for the ground surface, and the highest point on the uncapped well casing. Tolerances were found to be within the  $\pm 0.05$  foot requirement.

### **2.5 AQUIFER CHARACTERIZATION**

#### **2.5.1 Slug Tests**

In order to better understand the fate and transport of foreign constituents within the LBAD aquifer, it was determined that slug tests should be conducted. The wells tested were located around areas which had been previously identified as areas of suspected impact. At the time of testing, all wells on-site were installed at first water using 10-foot screens. The data resulting from these tests were then used to better locate a subsequent set of installed monitoring wells.

Eighteen "slug" tests were conducted on ten separate groundwater monitoring wells at LBAD. The following standard test procedure was used. A slug was constructed using Schedule 40 PVC pipe with an outside diameter of 2.38 inches in a length of 62 inches. The slug was filled with silica sand to provide sufficient ballast. This slug was rapidly inserted (slug in ) or removed (slug out) after the starting water level was measured and recorded in the 4 inch inside diameter groundwater monitoring well. Once the slug was inserted (or removed) water levels were measured using an electric water level tape with time until the water level recovered to near its original level in the well.

Each test was evaluated using the Bouwer and Rice (1976) method for partially penetrating wells. This method calculates the hydraulic conductivity (k) based on the following equation:

EQUATION 2-1

$$K = \frac{r_c^2 \ln(R_e/r_w)}{2d} \frac{1}{t} \ln \frac{h_o}{h_i}$$

where

- $r_c$  = radius of the unscreened part of the well where the head is rising
- $r_w$  = horizontal distance from well to center undisturbed aquifer
- $R_e$  = radial distance over which the difference in head,  $h_o$ , is dissipated in the flowing system of the aquifer
- $d$  = length of the well screen or open section of the well
- $h_o$  = head in the well at time  $t_o = 0$
- $h_i$  = head in the well at time  $t > t_o$
- $t$  = time since  $h_o$

for partially penetrating wells,

EQUATION 2-2:

$$\ln \frac{R_e}{r_w} = \left[ \frac{1.1}{\ln(b/r_w)} + \frac{A+B \ln[(D-b)/r_w]}{d/r_w} \right]^{-1}$$

At LBAD, the radius of the unscreened part of the well ( $r_c$ ) is 4 inches, the radius of the well in the screened interval ( $r_w$ )(to undisturbed aquifer) is 4 inches, and the length of the well screen is 10 feet. The length of the well screen was 10 feet on all the wells slug tested because they were all shallow wells. All shallow wells had 10-foot screens and all deep wells had 20-foot screens, based on the rationale explained in Section 2.4.2 of this document. On semi-log paper (see Appendix H), time and head data were plotted. A straight line was fitted through the same time data. Based on an arbitrary value of time, the value for  $(1/t) \ln(h_o/h_i)$  was calculated. Values for A and B were determined using standard Bouwer and Rice curves relating these parameters to  $(d/r_w)$ . The value for  $\ln(R_e/r_w)$  was then calculated. The hydraulic conductivity (k) was calculated using Equation 2-1 based on the calculated values of  $\ln(R_e/r_w)$  using Equation 2-2.

The mean hydraulic conductivity for all eighteen tests is  $3.542 \times 10^{-3}$ .



	IN	OUT	K(cm/sec)
MW-2	X		1.298x10 <sup>-2</sup>
MW-6	X	X	3.885x10 <sup>-3</sup> 3.718x10 <sup>-3</sup>
MW-7	X	X	3.825x10 <sup>-3</sup> 4.602x10 <sup>-3</sup>
MW-8	X		8.886x10 <sup>-4</sup>
MW-9	X		2.360x10 <sup>-4</sup>
MW-16	X	X	1.787x10 <sup>-3</sup>
MW-18	X		3.128x10 <sup>-3</sup>
MW-2		X	1.490x10 <sup>-2</sup>
MW-3	X	X	9.423x10 <sup>-1</sup> 5.482x10 <sup>-4</sup>
MW-4	X	X	1.172x10 <sup>-3</sup> 1.008x10 <sup>-3</sup>
MW-5	X	X	2.400x10 <sup>-3</sup> 4.109x10 <sup>-3</sup>
10 wells	10	8	Mean 3.542 x 10 <sup>-3</sup>

## 2.5.2 Pumping Test/Aquifer Test

### 2.5.2.1 Introduction

An aquifer test of approximately 50 hours duration was made at the Lexington-Bluegrass Army Depot, beginning at 8:00 AM, August 28, 1993. The test was made to determine the hydraulic properties of the limestone aquifer in the vicinity of the Sanitary and Industrial Waste Landfill, located north of L Street and west of 2nd Street.

The test was conducted to help determine the yield and flow characteristics of the limestone aquifer in anticipation that a pump and treat groundwater recovery system might be installed to capture contaminants potentially coming from the landfill.

### 2.5.2.2 Aquifer Test

It was originally planned to use MW-32, as the pumping well. A step drawdown test was conducted to determine the optimum pumping rate at well MW-32. It was determined at that time that the well

efficiency of the well was so low that it could not be used as a pumping well. Piezometer 1 was to be installed approximately 10 feet east of monitoring well MW-32. It was decided that Piezometer 1 would be drilled, and used as an open hole pumping well, and MW-32 would be substituted as an observation well. Therefore, the pumping well (PW) was drilled 10.3 feet east of monitoring well MW-32, about 525 feet south of the Sanitary and Industrial Waste Landfill and about 100 feet south of L Street. Figure 2-6 shows the location of the pumped well and the complete layout of all wells monitored during the test.

The pumped well was 6.75 inches in diameter and 55 feet deep. As previously stated, it was completed as an open hole well in order to maximize the well efficiency. It should be noted that after the conclusion of the test, the pumping well was finished as a piezometer with well screen, sand pack, bentonite seal, etc., as described in Section 2.4.2.3 - Piezometers. The pumping was conducted using a 4-inch Grunfos® pump with a 1-inch discharge hose. Discharge was controlled by a gate valve at the discharge end of the hose. The pump discharged into a 55-gal drum which was equipped with a graduated staff. This allowed the discharge rate to be measured using a stop watch. The pump rate was also periodically checked using a 5-gallon bucket graduated at one gallon increments and a stop watch to assure pump rate calibration. All generated water was pumped to the on-site sanitary sewer.

The water level in the pumped well and in 12 observation wells was monitored and the drawdown recorded during the test. The pumping well and the wells which were believed to be the most crucial (MW-32, MW-32D, P-2, P-3, P-4, and MW-7) and the background well (MW-40) were measured using transducers and a Hermit® data logger. These measurements were periodically confirmed using an electric water level tape. All other observation wells were measured using an electrical tape.

Listed below are the depths, pre-pumping water levels, and other information for the pumped well and observation wells. The wells are listed in the table according to their distance from the pumped well.

Well	Distance from Pumped Well (ft)	Depth of Well (ft)	Depth to First Water (ft) <sup>1</sup>	Depth to Water 8/28/93 (ft) <sup>2</sup>
PW(P1)	-	55	45	33.66
MW-32	10.3	54	44	37.47
P-2	37	42	39	32
P-3	75	55	50	40.1
MW-33	320	62	52	28.69

Well	Distance from Pumped Well (ft)	Depth of Well (ft)	Depth to First Water (ft) <sup>1</sup>	Depth to Water 8/28/93 (ft) <sup>2</sup>
MW-18-S	393	69	49	39.21
MW-7	875	82	69	55.2
MW-9	875	69	58	38.22
MW-46	1200	51	41	13.38
MW-40	1850	32	23	19.01
MW-16	1977	23	12	13.38

<sup>1</sup> Reported in the boring log when well was drilled.

<sup>2</sup> Below top of casing.

### 2.5.2.3 Interpretation of Data

Figures 2-7 through 2-17 are semi-logarithmic graphs of drawdown versus time in the pumped well (PW) and ten observation wells at the LBAD site. Values of transmissivity and storativity were calculated from the straight-line portion of the graphs. Analysis was based on the method described by Cooper and Jacob, 1946<sup>1</sup>, and illustrated by the calculations on the graphs. The transmissivity and storativity for each well, and the total drawdown after 3,000 minutes of pumping, are listed below:

Well	Drawdown, in ft, After 3,000 Minutes	Transmissivity (T) (gal/d-ft)	Storativity (S) (dimensionless)
PW	20.3	211	-
MW-32	-	197	$2.0 \times 10^{-4}$
P-2	-	129	$5.5 \times 10^{-5}$
P-3	8.6	209	$6.8 \times 10^{-5}$
MW-33	3.38	668	$2.9 \times 10^{-5}$
MW-18-S	5.1	391	$5.7 \times 10^{-6}$
MW-7	1.82	695	$3.5 \times 10^{-5}$
MW-9	1.71	503	$6.2 \times 10^{-5}$

1. Cooper, H. H. and Jacob, C. E., 1946, *A generalized graphical method for calculating formation constants and summarizing well field history*. Am. Geophys. Union Trans. vol. 27, pp 526-534.

Well	Drawdown, in ft, After 3,000 Minutes	Transmissivity (T) (gal/d-ft)	Storativity (S) (dimensionless)
MW-46	1.80	744	$1.8 \times 10^{-5}$
MW-40	0.08	-	-
MW-16	1.78	-	-
<b>Averages</b>		<b>416</b>	<b><math>5.9 \times 10^{-5}</math></b>

Transmissivity ranges from 129 to 744 gallons per day per foot (gal/d/ft) and averages 416 gal/d/ft. If the larger values are omitted, those for MW-33, MW-7, MW-9, and MW-46, all relatively far from the pumped well, the average is 227 gal/d-ft, which is considered more representative of the aquifer in the vicinity of the pumped well. Storativities, also computed from the straight-line portions of the graphs, were in the artesian range, averaging  $5.9 \times 10^{-5}$ . If the values for the same four wells are omitted, the average is  $8 \times 10^{-5}$ .

The low storativities, plus observations in the field when the wells were drilled, suggest a confined aquifer system. When the wells were drilled, water invariably rose in the hole after water was first encountered, suggestive of confined conditions. However, water table or unconfined conditions are believed to prevail at the LBAD site. Water occurs in joints and other openings in the rocks at various depths, but in shallow wells, it seeks a common level that is the water table. A well may not intersect a water-filled opening precisely at the water table with the result that when water finally is encountered in drilling, it typically rises in the hole. Walker, 1956<sup>2</sup>, writing about the occurrence of water in limestone in the Hopkinsville area in southwestern Kentucky, explains the condition as follows:

Many people in the area of this report would say that their wells were artesian, because the water rose in the wells after the drillers struck the water-bearing crevices. Drillers tell of how "rivers of water" surge out of some of the larger crevices they strike. Strictly speaking, however, an artesian well is one in which the water rises and stands above the water-saturated zone. Such is the case in only a few wells, for water occurs under water-table conditions almost everywhere in the quadrangle. It is normal for water to rise after being met, even though water-table conditions prevail. The crevices are so few and scattered that only very rarely would a well find one right at the water table. The average well reaches the level of the water table and continues some distance in tight rock before meeting a crevice. The water in it is under pressure and rises in the hole, but

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<sup>2</sup> Walker, E. H., 1956, *Groundwater resources of the Hopkinsville quadrangle, Kentucky*: U.S. Geological Survey Water-Supply Paper 1328.

only to the level of water in nearby openings such as crevices or wells, which is the water table. Naturally some wells find crevices a shorter distance below water table than others in the vicinity; water rises most in the wells that go deepest below the water table to find a crevice.

The storativity of unconfined sand and gravel aquifers typically ranges from 0.15 to 0.25. In such aquifers water occurs in the pore spaces between the individual grains which make up a relatively large part of the aquifers. The storativity at LBAD is low because the ratio of openings in the rocks to the rock matrix in which they occur is also very low. When a well is pumped in such an aquifer it responds as through confined in that pumping effects are transmitted rapidly, and typically over large distances.

At LBAD, for example, there was discernible drawdown in MW-46, about 1,200 feet from the pumped well, after less than 100 minutes of pumping (see Figure 2-15). The other observation wells also responded rapidly, as shown by the time-drawdown graphs of these wells.

The time-drawdown graphs of P-3 and MW-18S show that the drawdown rate decreased markedly after about 300 minutes of pumping, as indicated by the change in slope of the data plots. Such changes in slope indicate recharge, either from a source lateral to the wells such as water-filled cavities intersected by the expanding cone of depression, or local sources such as induced leakage from beds above or below the screened interval in the observation wells. Recharge to wells P3 and MW-18S is believed to be local and to represent induced leakage consequent upon the lowering of water levels of about 7.5 feet in P3 and 4 feet in MW-18S.

A lateral source of recharge was ruled out by a determination of boundary distances from the respective wells based on image-well theory. In this procedure, the distance from each observation well to a corresponding image well is calculated and arcs are drawn at the computed distances from the wells. If the arcs intersect, the point of intersection locates the image well. The boundary (recharge or discharge) is the midpoint of a line connecting the image well and the pumped well. This procedure yielded an indeterminate result when applied to the data from wells P3 and MW-18S. The computed distance to the image well was 511 feet for P3 and 2,650 feet for MW-18S, indicating little or no chance that the changes in slope in the time drawdown plots for these wells represent distant boundaries. If such boundaries were real, the drawdown in the other wells also would have been affected.

Two of the time-drawdown graphs, those for wells P-2 and MW-32 (Figures 2-9 and 2-8) show abrupt leveling of the data plots after pumping had gone on for 100 to 200 minutes. The reason is that in each

well, the water level was drawn down to the bottom of the screen, below which is a small sump from which water cannot escape. This caused the water level to remain without change for the remainder of the test.

The rate of drawdown in the pumped well and in the two closest wells, MW-32 (10.3 feet away) and P-2 (37 feet away) was nearly the same up to the time these wells were dewatered. To illustrate, after 100 minutes of pumping (just before P-2 was dewatered), the drawdown in the pumped well was 13.2 feet; in MW-32 it was 12.3 feet, and in P-2 the drawdown was 12.7 feet. Assuming some well loss in the pumped well (it would be small because of the low pumping rate), the drawdown was very nearly the same in all three wells. By contrast, the drawdown in well P3, the next closest well to the pumped well at 75 feet away, was only 5.3 feet after 100 minutes of pumping. This evidence suggests that the pumped well and wells MW-32 and P-2 were all in a single, highly permeable zone, perhaps a joint system in which the main opening extended southeast from the pumped well to P-2, with secondary openings extending to the west of the pumped well to include MW-32. Note that the drawdown in P-2 at 37 feet from the pumped well was greater than that in MW-32, only 10.3 feet away. If the pumped well was in a highly permeable joint system it would be the equivalent hydraulically to a well of very large diameter. Note that on the time-drawdown graph of the pumped well, Figure 2-7, no calculation is shown for storativity. The reason is that the nominal radius of a pumped well, especially a well in a heterogeneous aquifer, is almost never the same as its effective radius which is requisite to the storativity calculation. Use of the nominal well radius (0.28 ft) in the calculation gives an impossibly large value for storativity. If, however, we assume a value for pumped well storativity of  $5.5 \times 10^{-5}$ , the same as determined for well P-2, and solve for well radius, it comes out to 13.6 feet. If we use a storativity of  $2 \times 10^{-4}$ , determined for MW-32, the calculation yields a value for pumped well radius of 7.1 feet. The average value of these two values is 10.3 feet.

Figure 2-18 is a semi-logarithmic graph of drawdown vs. distance in the pumped and observation wells after 3,000 minutes of pumping, with an assumed radius for the pumped well of 10 feet. Calculations based on an "average" line drawn through the plotted points yields values for transmissivity and storativity of 227 gal/d/ft and  $5.3 \times 10^{-4}$  which fall within the range of values determined for the individual wells from the time-drawdown graphs.

#### 2.5.2.4 Effects of Pumping

Discernible pumping effects resulting from the 50-hour test extended over a very large area, perhaps as much as 150 acres as indicated by the drawdown measured in the observation wells. The growth of the cone of depression does not depend on the pumping rate, but only on aquifer characteristics and time of pumping. Doubling the pumping rate doubles the drawdown of any point within the cone, but the extent of the cone is the same for a given time of pumping no matter what the pumping rate.

The drawdown caused by pumping will not be symmetrical in this heterogeneous aquifer in which groundwater occurs and moves in joints and other openings in the rocks. Drawdown will also be influenced by prevailing groundwater gradients. Prior to the test, groundwater was moving generally southward in the test area as shown by the water table contours in Figure 2-19, based on measurements made just prior to the pumping test. The southern gradient would cause the cone of depression to be somewhat compressed north of the pumped well and spread out south of the pumped well, causing a slight elongation of the cone in a north-south direction. The prevailing gradient is slight, however, and the effect probably minimal. The shape of the cone no doubt was affected far more by the system of joints and other openings in the rocks than by the antecedent general gradient.

There are too few data points on which to base a highly detailed contour map of the cone of depression. Figure 2-20 shows the hypothetical shape of the cone based on the "average" line on the distance-drawdown graph in Figure 2-18. Also shown are measured drawdowns in the observation wells after 3,000 minutes (50 hours) of pumping.

Figure 2-21 is a contour map in which an effort has been made to adjust the contours to conform to the measured drawdown values. The paucity of data points is apparent from the map and is emphasized by the question marks in areas where critical data are lacking. The map in Figure 2-21, however, does convey a fair idea of the wide extent of the cone that was formed after only 50 hours of pumping. The contours show the general direction of flow at various points within the cone.

#### 2.5.3 Dye Trace Test

Between November, 1993 and June, 1994, a dye trace test was conducted in the vicinity of the Industrial and Sanitary Waste Landfill.



After extensive reconnaissance, forty-three potential recovery sites were identified. These discharge points consisted of 14 monitoring wells, 17 seeps or springs, 11 stream locations, and one pumping well at the Prestress concrete Inc. facility.

A background fluorescence study was conducted by placing a passive dye detector consisting of activated carbon and dye-free cotton cloth at each potential dye recovery point. These dye detectors were exchanged and analyzed weekly. The detectors were analyzed for dyes potentially useful in the study: fluorescein, rhodamine-WT, and eosine. High background levels of fluorescein were detected in the aquifer. Rhodamine-WT was not found in the aquifer, but has a tendency to be readily sorbed by shales which are present in the LBAD lithology. Eosine was chosen for the dye test due to its high level of detectability and its very low tendency to sorb onto shales.

Due to the presence of a pumping well at Prestress Concrete, Inc., it was decided that every effort would be made to inject an amount of dye large enough to be detected by analytical instruments but small enough not to be detected visually. The amount of dye injected was determined on the basis of the quantity of spring-flow at the time of injection, the probable distance the dye would travel, and past experience in geologically similar situations.

A total of two dye injections were performed. The first took place on April 8, 1994. Four pounds of eosine dye were introduced into well MW-07 and flushed into the aquifer with approximately 2000 gallons of potable water. No significant amount of dye was detected in any of the monitoring points. Therefore, on May 11, 1994, a second injection was made using 8 pounds of eosine dye which was flushed into the aquifer using 2000 gallons of potable water.

Although there were low levels of dye detected, the levels were such that they were not significantly above background levels. If significant conduit porosity was present, the dye should have appeared in the dye detectors at concentrations several orders of magnitude above background levels.

It can be concluded that no significant conduit flow is associated with the dye injection point and probably not with the entire landfill site. The lack of dye recovery within the period of dye monitoring suggests that ground water flow was slow, and of an order of magnitude that was more characteristic of fracture flow or granular flow than of conduit flow associated with more mature karst aquifers. A more detailed explanation of the dye trace test performed at LBAD is in Appendix I.

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**TABLE 2-1  
WELL DATA  
LEXINGTON-BLUEGRASS ARMY DEPOT**

WELL NUMBER	DATE INSTALLED	GROUND ELEVATION (IN FEET) ***	DEPTH TO BEDROCK (IN FEET) ****	BEDROCK ELEVATION (IN FEET) ***	FIRST WATER ELEVATION (IN FEET) ***	TOTAL DEPTH OF HOLE (IN FEET) ****	TOTAL DEPTH ELEVATION (IN FEET) ***	1/10/92 WATER ELEVATION (IN FEET) ***	3/16/92 WATER ELEVATION (IN FEET) ***	9/21/92 WATER ELEVATION (IN FEET) ***	12/9/93 WATER ELEVATION (IN FEET) ***
MW-01	11/19/91	962.4	10.5	951.9	913.4	60.0	902.4	948.5	942.5	ABANDONED	ABANDONED
MW-02	11/21/91	965.0	6.3	958.7	931.0	43.0	922.0	935.6	935.7	934.9	934.0
MW-02D	07/29/92	963.5	7.5	956.0	891.5	80.5	883.0	*	*	889.1	921.1
MW-03	11/22/91	941.3	5.7	935.6	929.3	23.0	918.3	933.5	933.7	933.7	931.6
MW-04	11/08/91	932.9	5.0	927.9	915.9	29.0	903.9	932.6	932.8	932.9	930.7
MW-05	11/07/91	938.8	11.0	927.8	913.8	33.0	905.8	932.5	932.7	933.1	930.4
MW-06	11/20/91	957.3	8.0	949.3	932.3	35.0	922.3	934.9	934.7	934.1	932.9
MW-06D	07/29/92	957.9	7.5	950.4	917.9	72.5	885.4	*	*	887.4	901.2
MW-07	11/19/91	989.3	14.0	975.3	920.3	82.0	907.3	935.2	935.2	935.4	935.7
MW-08	11/11/91	953.6	10.0	943.6	934.1	31.0	922.6	949.8	950.0	946.4	947.7
MW-08D	08/04/92	952.3	8.0	944.3	912.3	64.0	888.3	*	*	937.2	938.8
MW-09	11/12/91	975.6	14.5	961.1	917.6	69.0	906.6	940.1	939.9	938.6	939.6
MW-1009	Δ	1022.6	12.0	1010.6	**	50.0	972.6	1011.6	1011.5	**	1009.3
MW-1051	Δ	954.1	**	**	**	**	**	934.8	935.1	934.6	923.3
MW-1052	Δ	955.8	**	**	**	**	**	935.0	935.8	926.4	916.7
MW-1053	Δ	952.7	1.0	951.7	**	27.0	925.7	934.2	**	932.6	932.2
MW-1121	Δ	957.3	8.0	949.3	**	32.0	925.3	949.6	950.5	947.9	950.0
MW-1122	Δ	945.7	6.0	939.7	**	31.0	914.7	939.7	939.4	**	939.3
MW-1123	Δ	977.1	15.0	962.1	**	37.0	940.1	973.4	974.0	971.7	971.1
MW-1124	Δ	949.2	3.5	945.7	**	15.0	934.2	948.2	949.1	945.3	946.9
MW-1132	Δ	998.0	9.0	989.0	**	30.0	968.0	978.5	989.4	**	993.7
MW-1133	Δ	1004.1	5.0	999.1	**	14.0	990.1	1003.1	1003.1	1001.6	1001.2

**TABLE 2-1  
WELL DATA  
LEXINGTON-BLUEGRASS ARMY DEPOT  
(Continued)**

WELL NUMBER	DATE INSTALLED	GROUND ELEVATION (IN FEET) ***	DEPTH TO BEDROCK (IN FEET) ****	BEDROCK ELEVATION (IN FEET) ***	FIRST WATER ELEVATION (IN FEET) ***	TOTAL DEPTH OF HOLE (IN FEET) ****	TOTAL DEPTH ELEVATION (IN FEET) ***	1/10/92 WATER ELEVATION (IN FEET) ***	3/16/92 WATER ELEVATION (IN FEET) ***	9/21/92 WATER ELEVATION (IN FEET) ***	12/9/93 WATER ELEVATION (IN FEET) ***
MW-1134	Δ	999.0	7.0	992.0	**	28.5	970.5	995.0	994.9	994.6	993.2
MW-1135	Δ	1009.9	**	**	**	**	**	**	**	1000.7	998.7
MW-16	11/22/91	942.8	5.5	937.3	930.8	23.0	919.8	932.7	932.7	933.0	930.7
MW-17	11/26/91	973.1	8.0	965.1	924.1	69.0	904.1	936.5	936.7	935.9	935.8
MW-18D	07/29/92	972.0	9.5	962.5	912.0	105.0	867.0	*	*	928.9	926.7
MW-19	05/11/92	942.1	4.6	937.5	920.1	32.0	910.1	*	*	932.7	931.2
MW-19DD	08/05/92	941.9	5.0	936.9	917.9	68.0	873.9	*	*	876.1	910.4
MW-22	07/21/92	1001.7	10.5	991.2	979.2	32.5	969.2	*	*	970.7	969.2
MW-22D	07/28/92	1001.9	15.8	986.1	954.4	67.5	934.4	*	*	935.1	934.6
MW-23	07/21/92	986.9	8.0	978.9	943.9	43.0	943.9	*	*	950.7	950.1
MW-23D	07/28/92	986.7	6.0	980.7	945.7	88.0	898.7	*	*	904.5	935.6
MW-32	07/23/92	968.7	7.6	961.1	924.7	54.0	914.7	*	*	935.5	933.2
MW-32D	08/04/92	968.7	8.0	960.7	923.7	89.5	879.2	*	*	884.4	915.5
MW-33	07/28/92	961.1	3.8	957.3	909.1	62.5	898.6	*	*	934.8	933.7
MW-35	07/22/92	952.7	6.2	946.5	941.7	24.5	928.2	*	*	929.3	928.8
MW-39D	07/29/92	953.1	5.7	947.4	918.1	81.5	871.6	*	*	875.0	914.8
MW-40	07/23/92	941.5	2.1	939.4	918.0	32.0	909.5	*	*	925.3	923.0
MW-40D	07/24/92	941.4	4.0	937.4	906.4	68.0	873.4	*	*	925.4	923.1
MW-41	07/23/92	936.3	6.0	930.3	920.3	26.0	910.3	*	*	926.4	923.3
MW-42	07/30/92	931.9	4.3	927.6	916.9	25.5	906.4	*	*	932.1	929.9
MW-43I	07/30/92	991.4	5.5	985.9	**	13.0	978.4	*	*	988.8	987.9

**TABLE 2-1**  
**WELL DATA**  
**LEXINGTON-BLUEGRASS ARMY DEPOT**  
**(Continued)**

WELL NUMBER	DATE INSTALLED	GROUND ELEVATION (IN FEET) ***	DEPTH TO BEDROCK (IN FEET) ****	BEDROCK ELEVATION (IN FEET) ***	FIRST WATER ELEVATION (IN FEET) ***	TOTAL DEPTH OF HOLE (IN FEET) ****	TOTAL DEPTH ELEVATION (IN FEET) ***	1/18/92 WATER ELEVATION (IN FEET) ***	3/16/92 WATER ELEVATION (IN FEET) ***	9/21/92 WATER ELEVATION (IN FEET) ***	12/9/93 WATER ELEVATION (IN FEET) ***
MW-44I	07/30/92	989.1	5.0	984.1	978.6	15.8	973.3	*	*	984.5	982.6
MW-45	08/05/92	953.0	8.0	945.0	941.0	42.0	911.0	*	*	938.9	940.0
MW-46	08/04/92	946.1	6.0	940.1	905.1	51.0	895.1	*	*	934.6	933.8
MW-47	08/07/92	960.0	11.0	949.0	929.5	39.0	921.0	*	*	934.6	933.0
MW-B47	08/28/93	937.4	11.0	926.4	907.4	40	897.4	*	*	*	927.4
MW-B47D	08/26/93	937.4	5.0	932.4	892.4	75	862.4	*	*	*	928.0
MW-48	09/08/93	939.7	5.0	934.7	910.7	38	901.7	*	*	*	**
MW-48D	09/08/93	939.7	5.0	934.7	910.7	73	866.7	*	*	*	**
P-1	09/07/93	968.8	6.0	962.8	923.8	60	908.8	*	*	*	935.6
P-2	08/26/93	93	963.0	6.0	957.0957.0	45	918.0	*	*	*	935.7
P-3	08/27/93	971.9	10.0	961.9	921.9	55	916.9	*	*	*	936.5
P-4	08/27/93	966.4	8.0	958.4	934.4	32	934.4	*	*	*	945.2

\* Well not installed  
\*\* Data not obtained  
\*\*\* Elevations in feet above mean sea level  
\*\*\*\* Depth in feet below ground surface  
Δ Previously installed wells (1981)

**TABLE 2-2  
DRY HOLE DATA  
LEXINGTON-BLUEGRASS ARMY DEPOT**

<b>WELL NUMBER</b>	<b>DATE DRILLED</b>	<b>SURFACE ELEVATION* (IN FEET)</b>	<b>DEPTH TO BEDROCK** (IN FEET)</b>	<b>BEDROCK ELEVATION (IN FEET)</b>	<b>TOTAL DEPTH DRILLED (IN FEET)**</b>	<b>TOTAL DEPTH ELEVATION* (IN FEET)</b>
MW-01	11/09/91	962.4	10.5	951.9	60.5	901.9
MW-10	11/18/91	1011.8	13.0	998.8	112.0	899.8
MW-11	11/19/91	1021.9	10.7	1011.2	125.0	896.9
MW-12	10/31/91	1035.7	7.5	1028.2	7.5	1028.2
MW-13	11/05/91	1016.2	5.5	1010.7	100.0	916.2
MW-14	11/04/91	1028.4	5.0	1023.4	5.0	1023.4
MW-15	11/04/91	1039.0	6.0	1033	6.0	1033.0
MW-17	11/25/91	962.1	12.5	949.6	75.0	887.1
MW-20	6/12/92	933.6	5.4	928.2	70.0	863.6
MW-21	6/13/92	934.2	5.5	928.7	43.0	891.2
MW-24	07/21/92	991.4	5.5	985.9	60.0	931.4
MW-25	07/22/92	1007.2	10.1	997.1	60.0	947.2
MW-26	07/22/92	987.1	7.7	979.4	60.0	927.1
MW-27	07/22/92	1018.1	11.0	1007.1	60.0	958.1
MW-28	07/22/92	1015.6	11.5	1004.1	60.0	955.6
MW-29	07/21/92	939.8	5.5	934.3	60.0	879.8
MW-31	07/21/92	980.4	17.5	962.9	60.0	920.4
MW-34	07/22/92	952.8	7.6	945.2	60.0	892.8
MW-36	07/22/92	984.2	8.7	975.5	60.0	924.2
MW-37	07/22/92	993.6	6.4	987.2	60.0	933.6
MW-38	07/22/92	977.3	6.5	970.8	60.0	917.3

\* Elevations in feet above mean sea level

\*\* Depth in feet below ground surface



TABLE 2-3  
WELL PURGE VOLUMES: DEVELOPMENT AND SAMPLING  
LEXINGTON-BLUEGRASS ARMY DEPOT

WELL NUMBER	DATE INSTALLED	REQUIRED PURGE VOLUME FOR DEVELOPMENT (IN GALLONS)	ACTUAL VOLUME REMOVED FOR DEVELOPMENT (IN GALLONS)	REQUIRED PURGE VOLUME FOR SAMPLING (IN GALLONS)	ACTUAL VOLUME REMOVED FOR SAMPLING (IN GALLONS)
MW-02	11/21/91	105.0	105.0	32.0	32.0
MW-02D	7/29/92	239.0	45.0	16.0	9.0
MW-03	11/22/91	53.0	95.0	31.8	44.0
MW-04	11/8/91	220.0	220.0	54.4	80.0
MW-05	11/7/91	70.0	70.0	48.8	110.0
MW-06	11/20/91	71.5	110.0	23.4	23.4
MW-06D	7/29/92	121.0	27.0	27.5	3.5
MW-07	11/19/91	85.0	160.0	53.0	70.0
MW-08	11/11/91	75.0	75.0	45.8	46.0
MW-08D	8/4/92	220.0	220.0	68.0	68.0
MW-09	11/12/91	98.0	70.0	82.9	55.0
MW-1009	*	*	*	65.0	66.0
MW-1051	*	*	*	43.0	43.0
MW-1052	*	*	*	45.5	22.0
MW-1053	*	*	*	29.0	29.0
MW-1121	*	*	*	42.0	28.0
MW-1122	*	*	*	45.0	22.0
MW-1123	*	*	*	61.0	51.0
MW-1124	*	*	*	28.0	27.0
MW-1132	*	*	*	48.0	20.0
MW-1133	*	*	*	17.0	6.0
MW-1134	*	*	*	42.5	17.5

TABLE 2-3  
WELL PURGE VOLUMES: DEVELOPMENT AND SAMPLING  
LEXINGTON-BLUEGRASS ARMY DEPOT  
(Continued)

WELL NUMBER	DATE INSTALLED	REQUIRED PURGE VOLUME FOR DEVELOPMENT (IN GALLONS)	ACTUAL VOLUME REMOVED FOR DEVELOPMENT (IN GALLONS)	REQUIRED PURGE VOLUME FOR SAMPLING (IN GALLONS)	ACTUAL VOLUME REMOVED FOR SAMPLING (IN GALLONS)
MW-1135	*	*	*	148.5	7.0
MW-16	11/22/91	160.0	160.0	24.4	55.0
MW-18	11/26/91	275.0	275.0	62.4	95.0
MW-18D	7/29/92	236.0	54.0	180.0	180.
MW-19	5/11/92	123.0	165.0	45.7	41.0
MW-19DD	8/5/92	233.0	58.0	58.0	5.0
MW-22	7/21/92	21.0	2.5	**	**
MW-22D	7/28/92	57.0	6.5	**	**
MW-23	7/21/92	85.0	85.0	75.0	75.0
MW-23D	7/28/92	216.0	60.0	60.0	1.5
MW-32	7/23/92	108.0	110.0	92.0	92.0
MW-32D	8/4/92	220.0	60.0	60.0	10.0
MW-33	7/28/92	141.0	150.0	110.0	110.0
MW-35	7/22/92	106.0	27.0	27.0	0.5
MW-39	7/29/92	239.0	63.0	24.0	7.0
MW-40	7/23/92	105.0	105.0	100.0	25.0
MW-40D	7/24/92	225.0	225.0	93.0	93.0
MW-41	7/23/92	93.0	93.0	120.0	120.0
MW-42	7/30/92	143.0	165.0	134.0	134.0
MW-43I	7/30/92	45.0	21.0	21.0	4.0
MW-44I	7/30/92	71.0	80.0	36.0	23.0



TABLE 2-3  
WELL PURGE VOLUMES: DEVELOPMENT AND SAMPLING  
LEXINGTON-BLUEGRASS ARMY DEPOT  
(Continued)

WELL NUMBER	DATE INSTALLED	REQUIRED PURGE VOLUME FOR DEVELOPMENT (IN GALLONS)	ACTUAL VOLUME REMOVED FOR DEVELOPMENT (IN GALLONS)	REQUIRED PURGE VOLUME FOR SAMPLING (IN GALLONS)	ACTUAL VOLUME REMOVED FOR SAMPLING (IN GALLONS)
MW-45	8/5/92	130.0	130.0	220.0	225.0
MW-46	8/4/92	150.0	150.0	173.5	100.0
MW-47	8/7/92	80.0	90.0	54.5	40.0
USGS WELL	*	*	*	200.0	200.0
MW-47B	08/28/93	110.0	110.0	165.0	165.0
MW-47BD	08/26/93	165.0	165.0	330.0	330.0
MW-48	09/08/93	220.0	220.0	225.0	225.0
MW-48D	09/08/93	250.0	250.0	250.0	250.0

\* Well previously installed and developed (USATHAMA, 1983).

\*\* Well Dry at time of sampling. Insert Table 2-3

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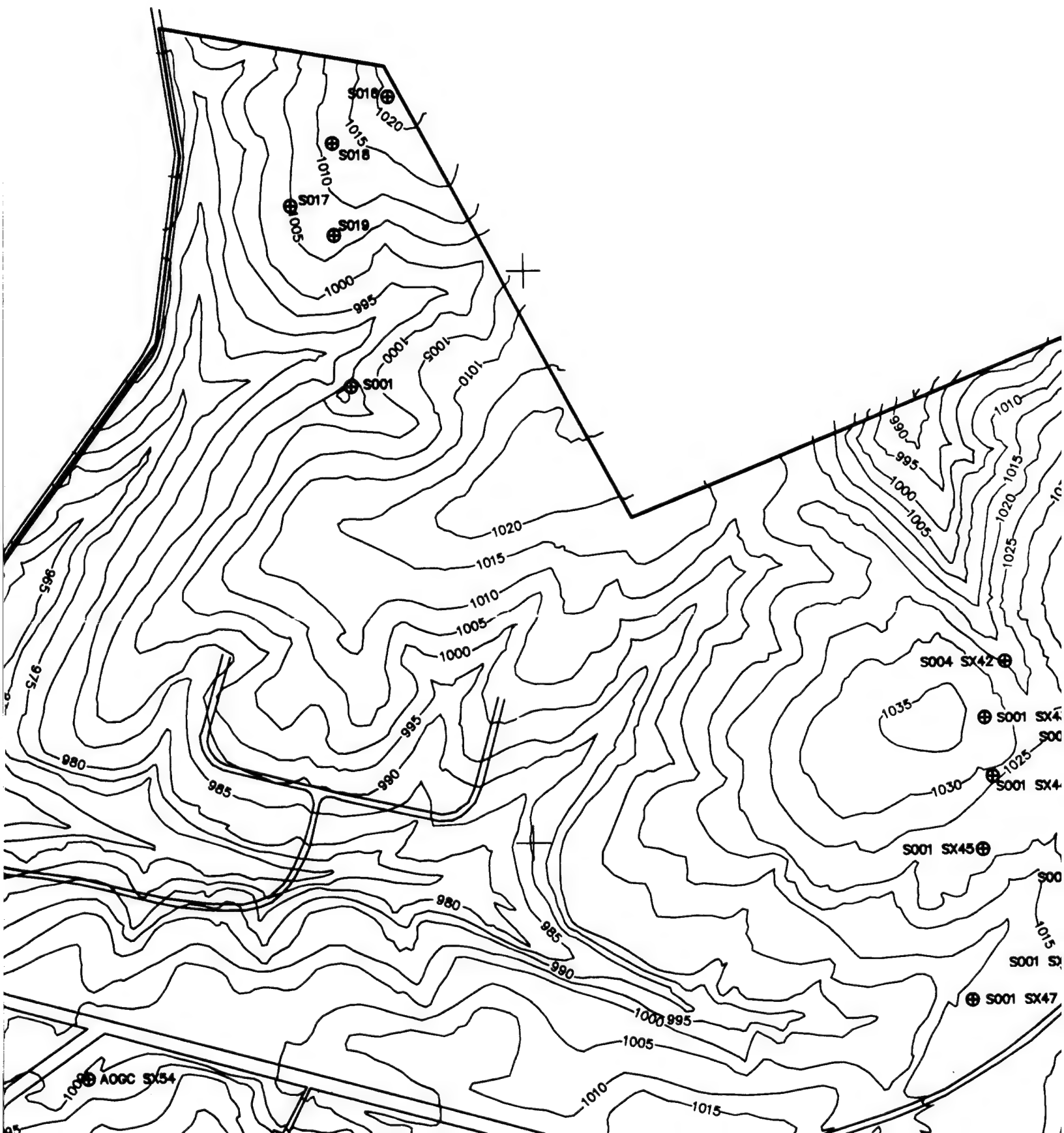
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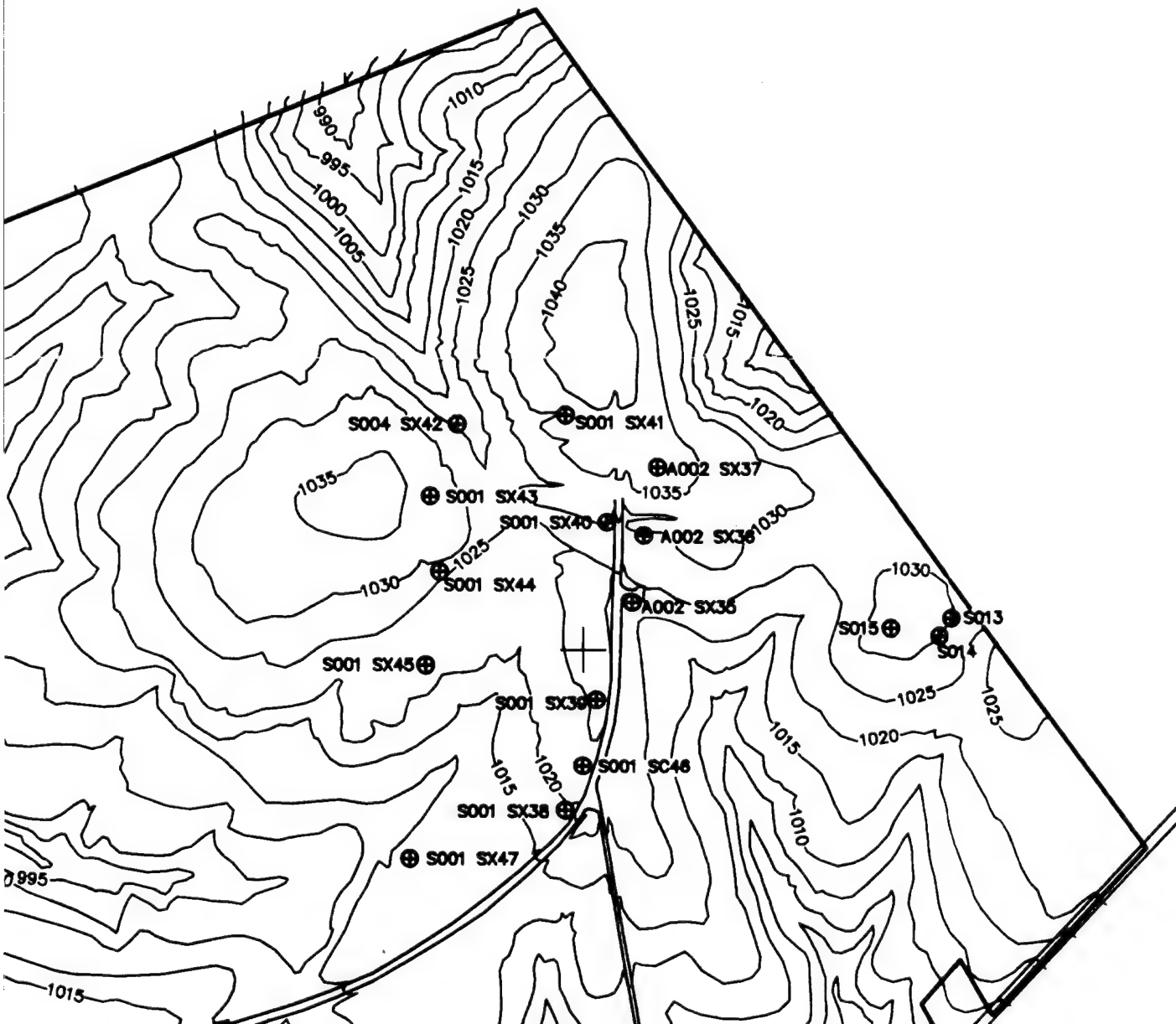
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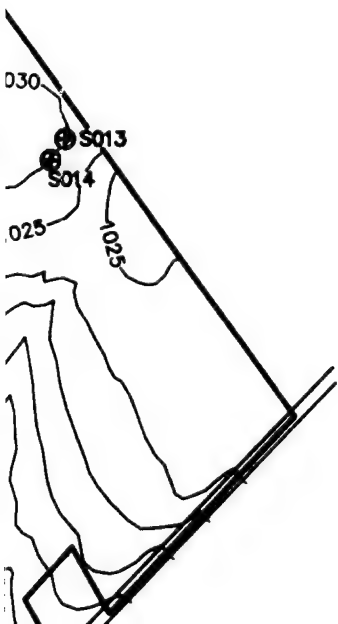
**Abstract**



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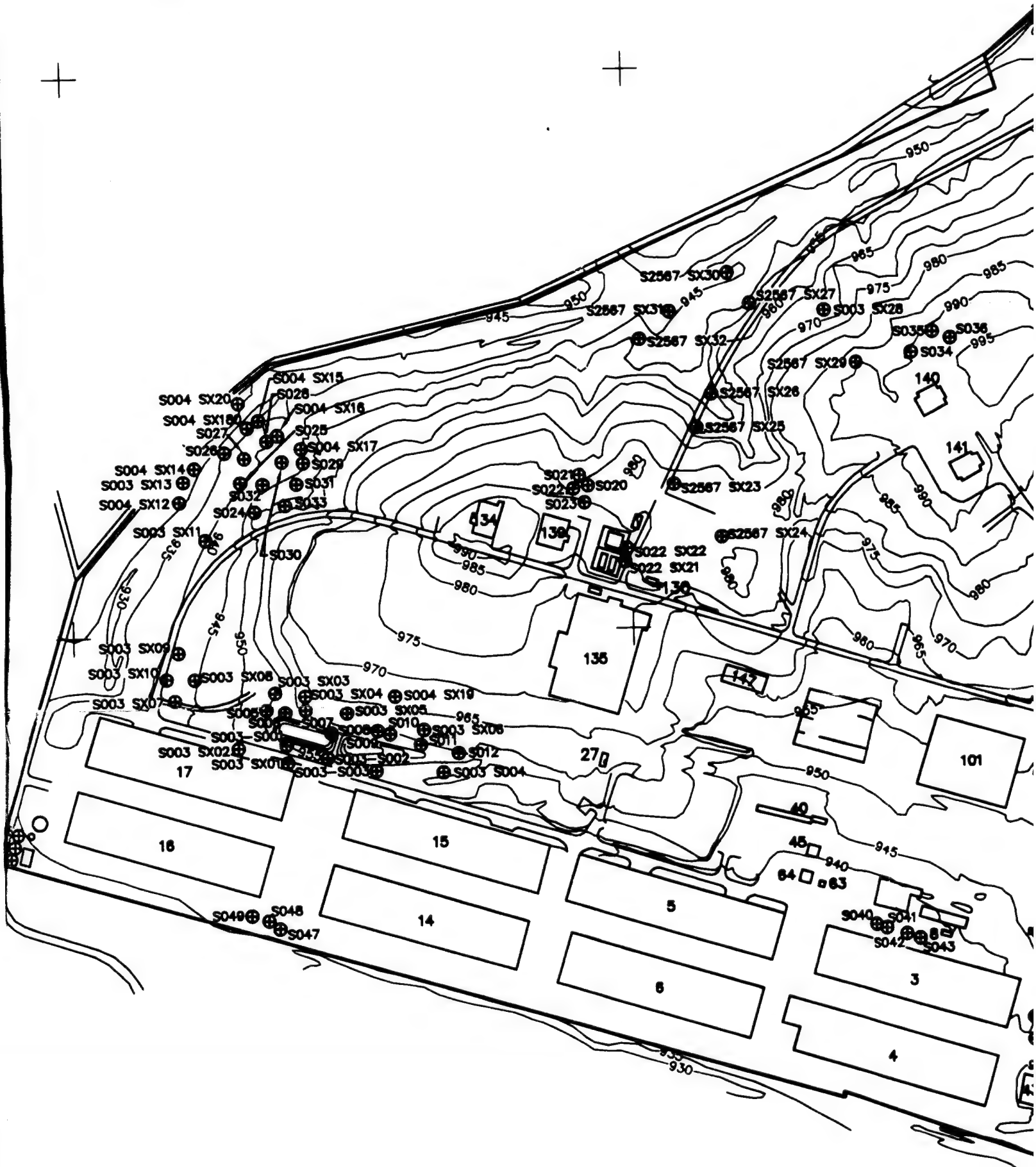
13 836 000N

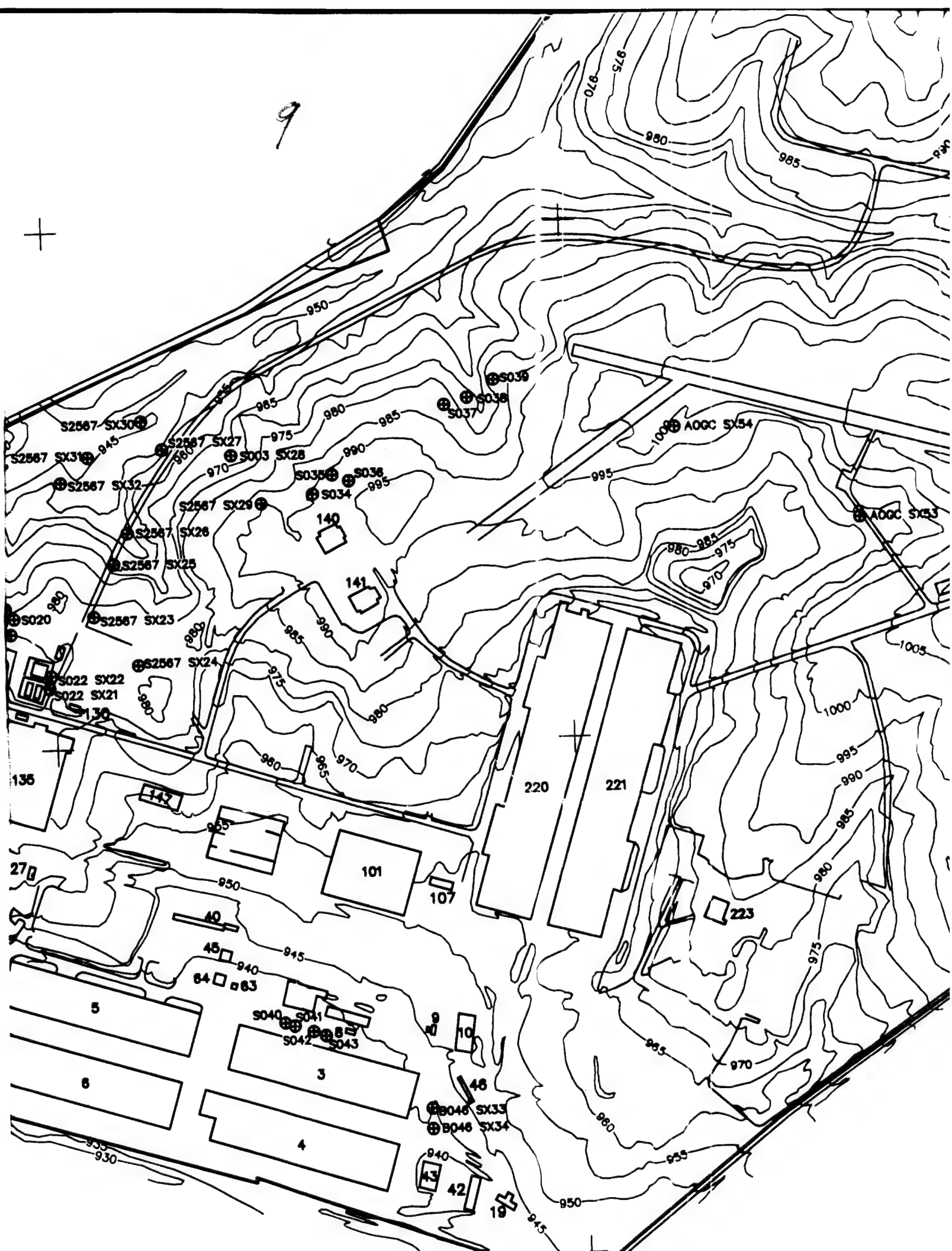
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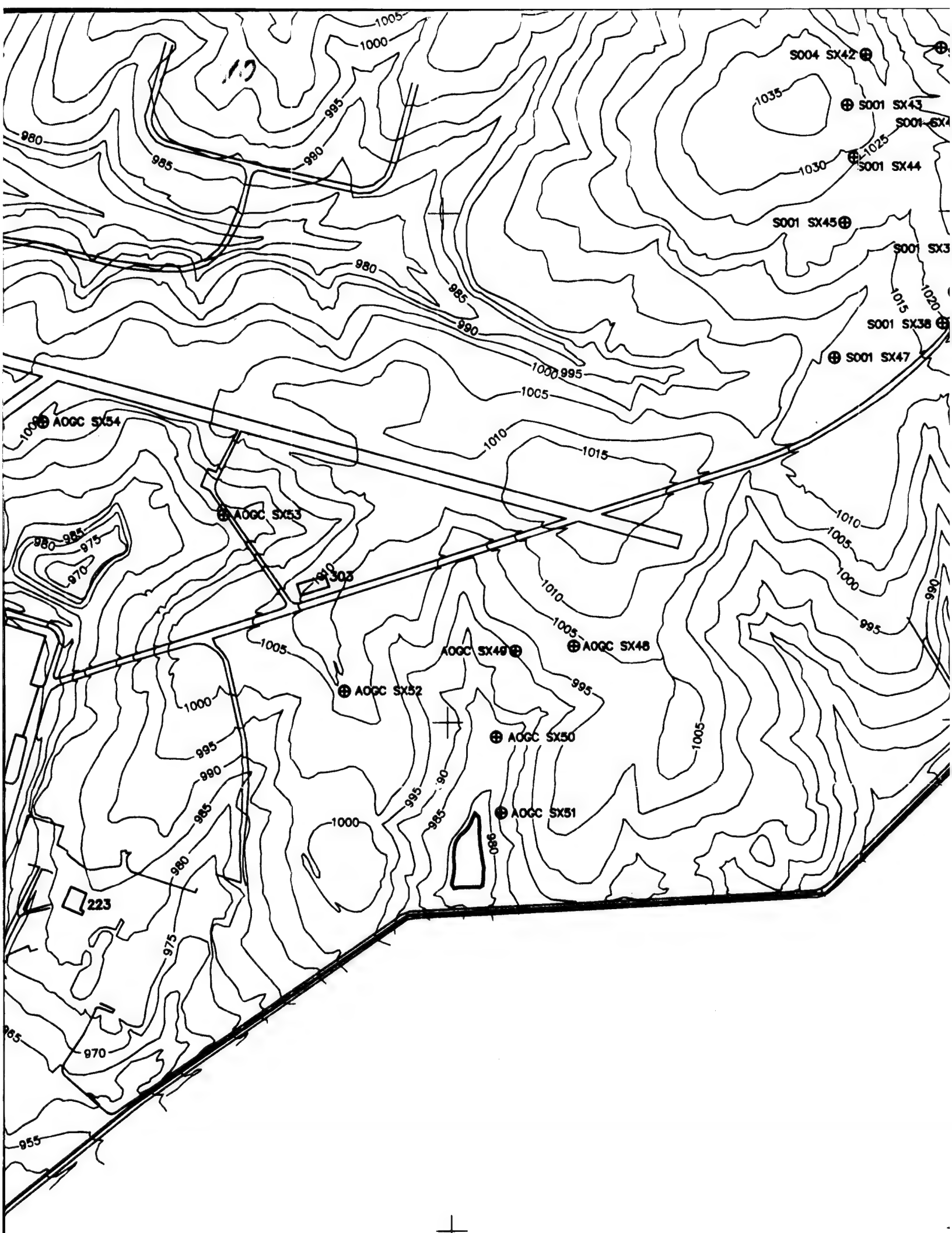
S0453  
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S0451

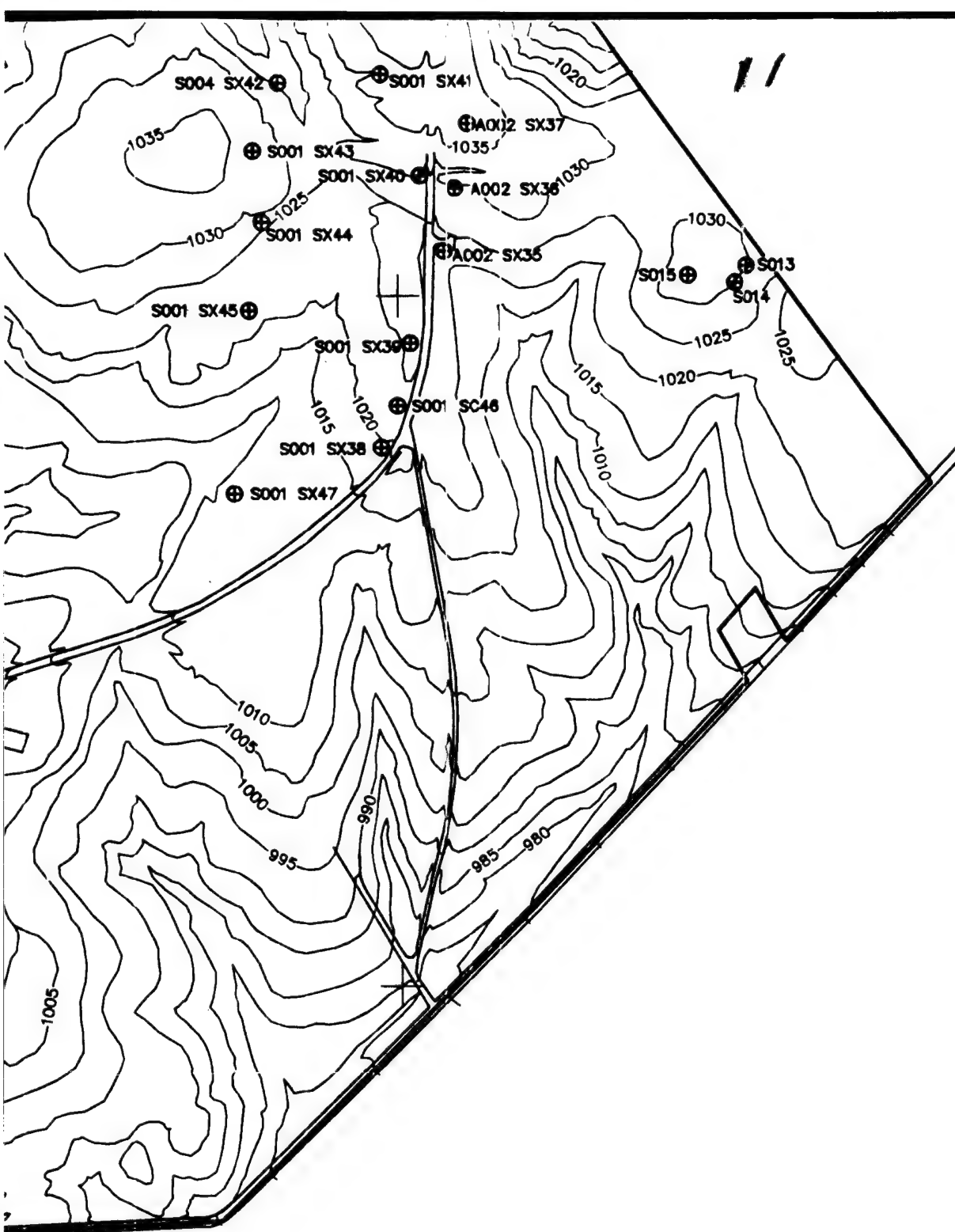


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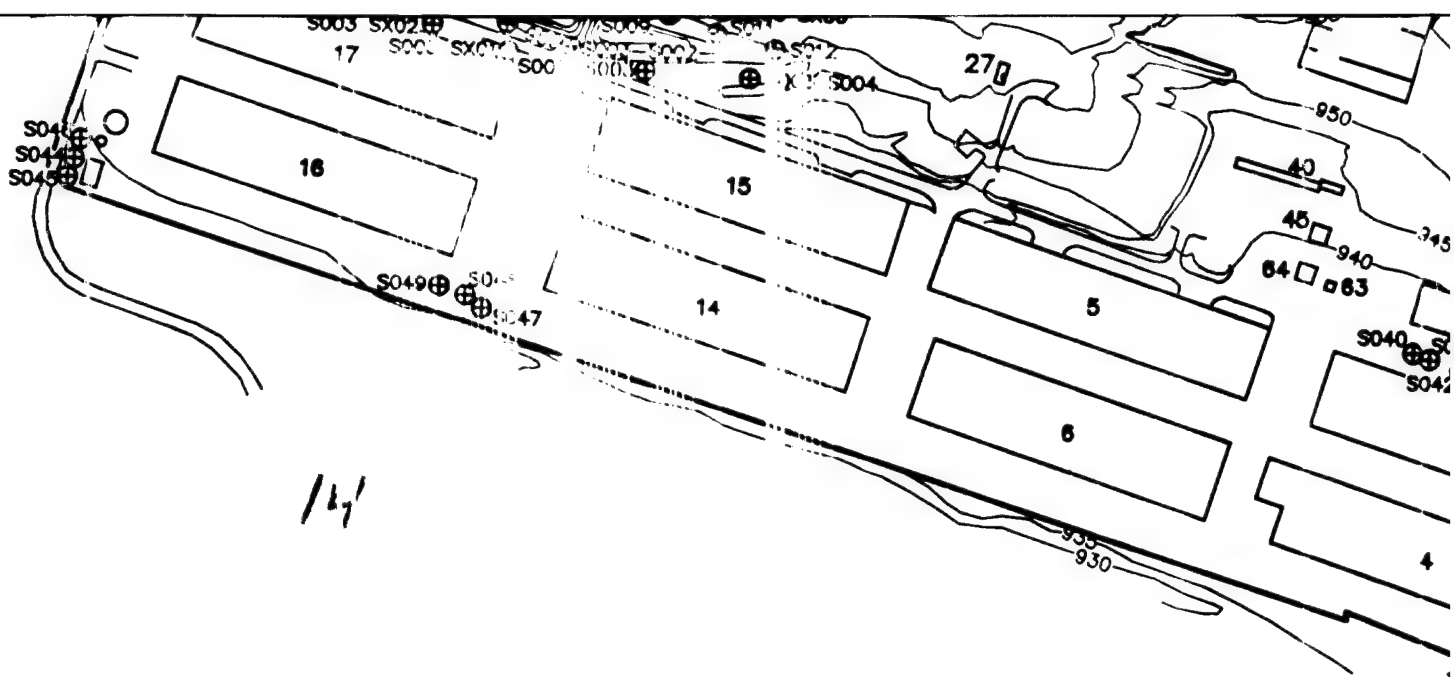
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NUMBER	DATE	MADE BY	CHECKED BY	DESCRIPTION
REVISIONS				



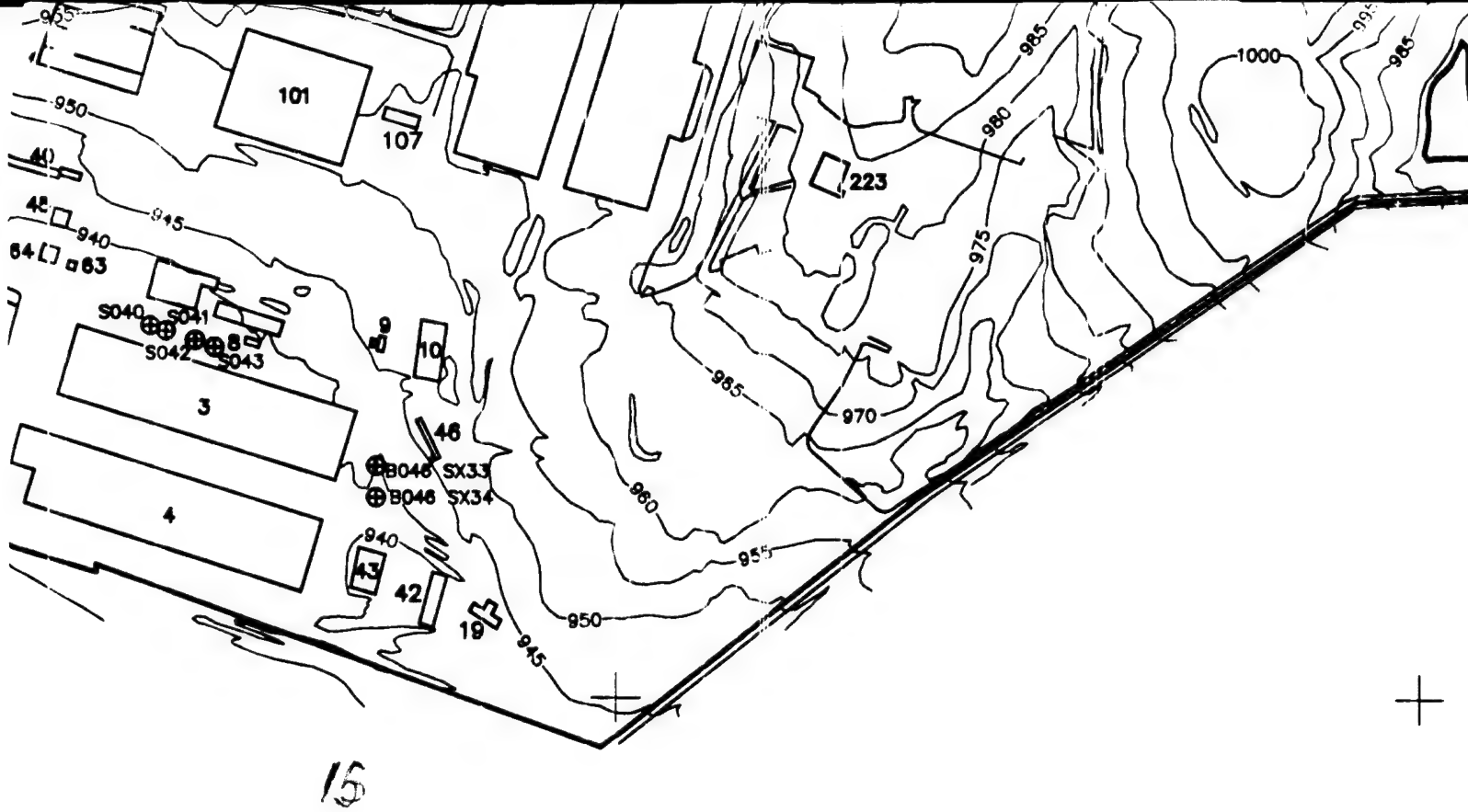
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**LEGEND**  
⊕ SOIL BORING

DESCRIPTION	DRAWN BY	
	CAP	
	DEPT. CHECK	
	PROJ. CHECK	



**M&E**

**Metcalf & Eddy**

SCALE: 1"

REG. PROF. ENGR.

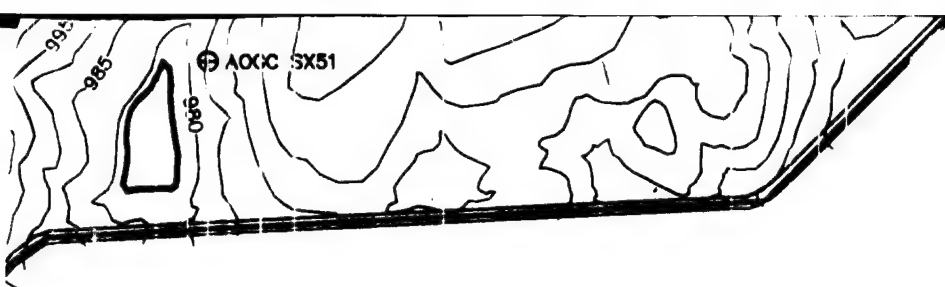
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SCALE: 1" = 437.44'



LEXINGTON BLUEGRASS A  
SOIL BORING SAMPLE L

LEXINGTON, KENTU

UNLESS OTHERWISE NOTED OR CHANGED BY REPRODUCTION

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RASS ARMY DEPOT

JOB 012308

MPLE LOCATIONS

FILE NO. 308-2-1

, KENTUCKY

FIGURE 2-1

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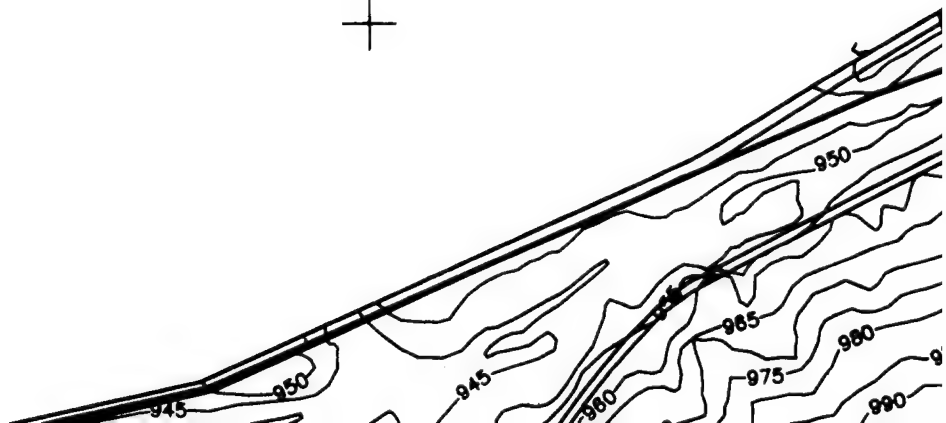
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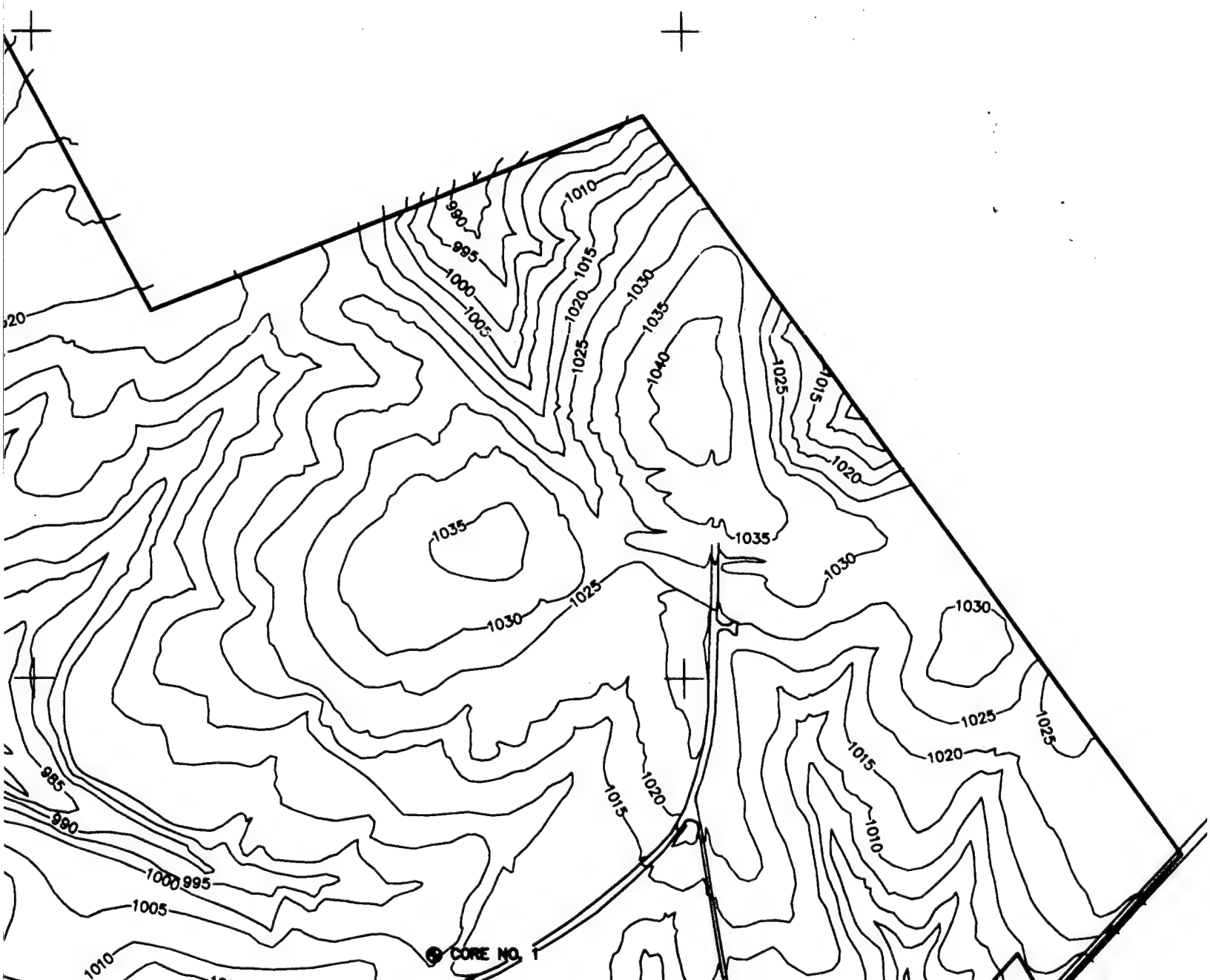
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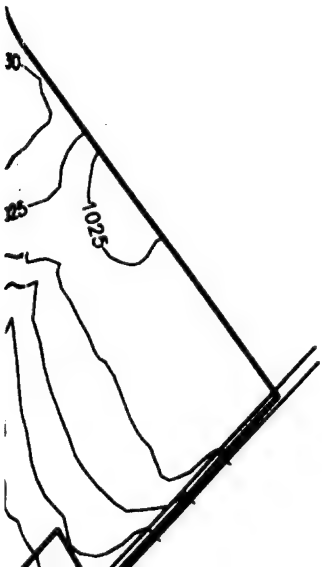


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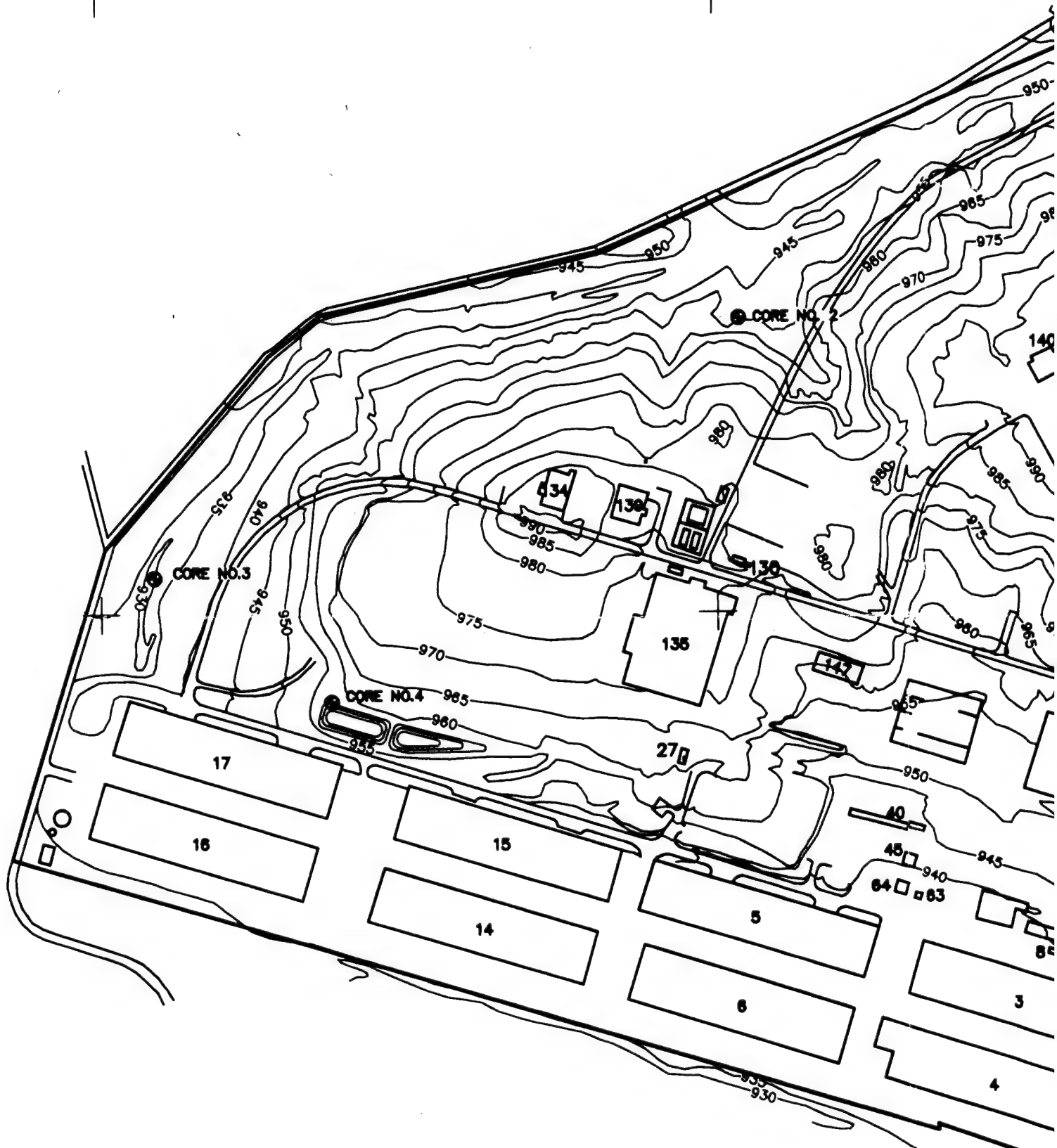


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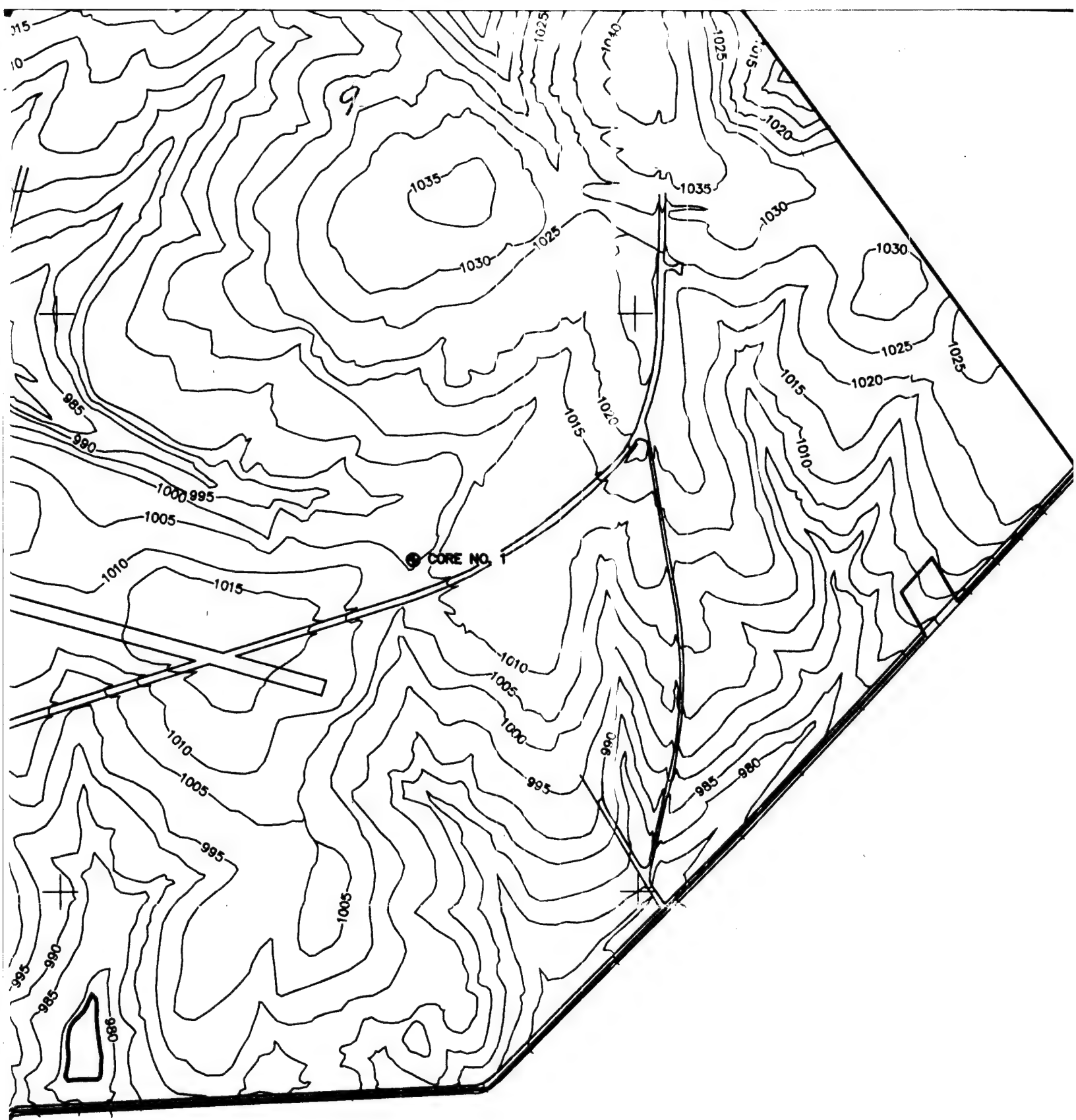
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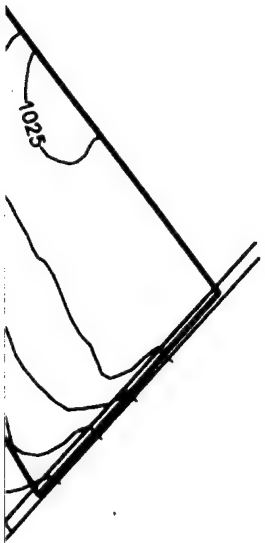
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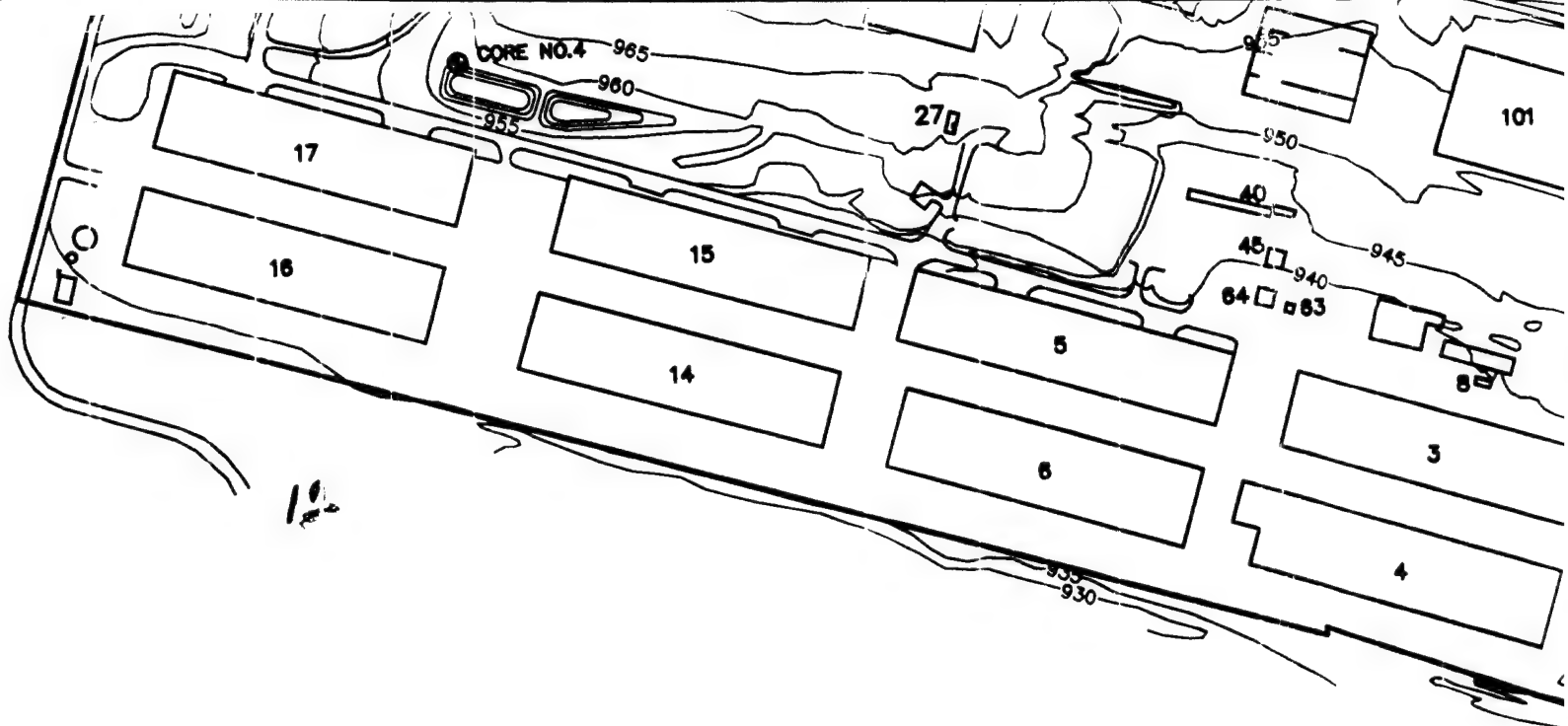
11

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REVISIONS				



**LEGEND**  
⊕ ROCK CORE SAMPLE

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	PROJ. CHECK	



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**M&E** Metcalf & Eddy

SCALE:

REG. PROF. ENGR.

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SCALE: 1" = 437.44'



LEXINGTON BLUEGRASS ARMY

ROCK CORE SAMPLE LO

LEXINGTON, KENTUCKY

LESS OTHERWISE NOTED OR CHANGED BY REPRODUCTION



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INGTON BLUEGRASS ARMY DEPOT

K CORE SAMPLE LOCATIONS

LEXINGTON, KENTUCKY

JOB 012308

FILE NO. 308-2-2

FIGURE 2-2

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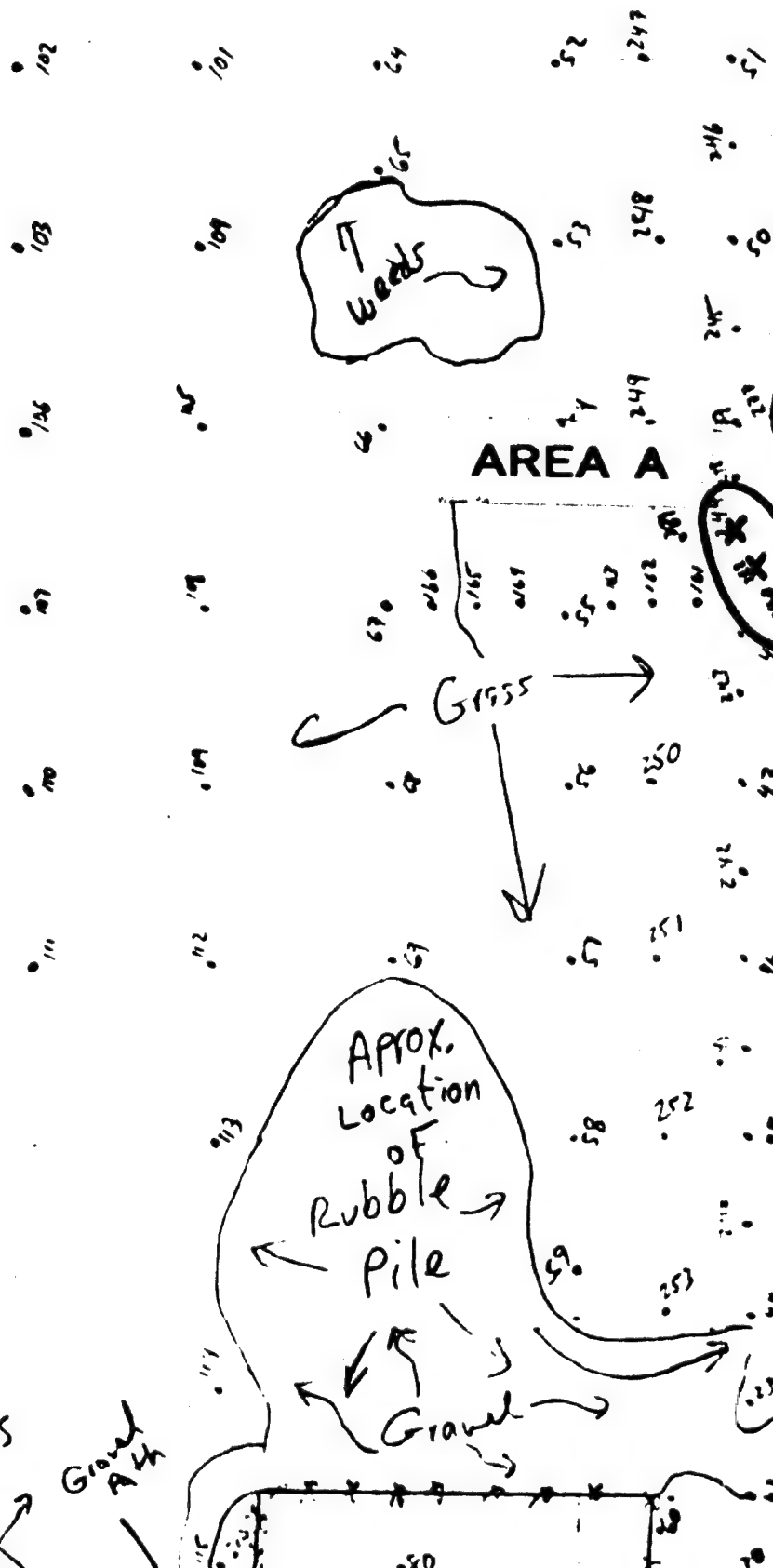
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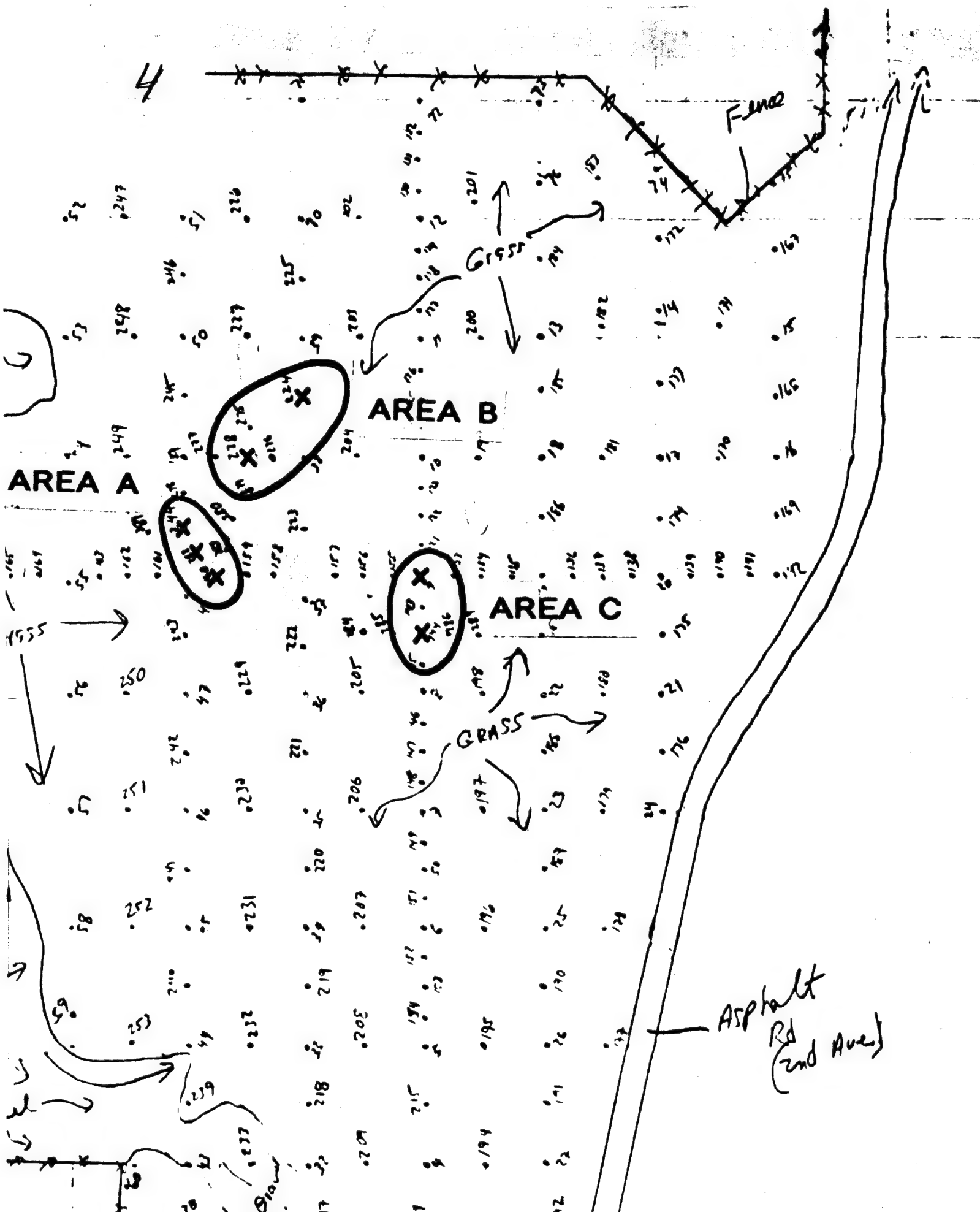
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GRASS

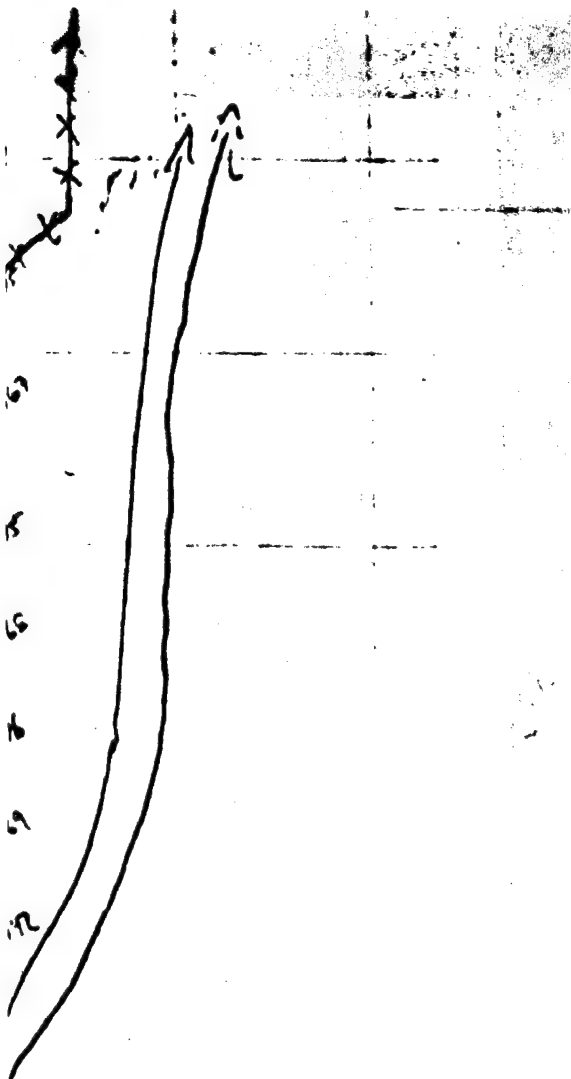




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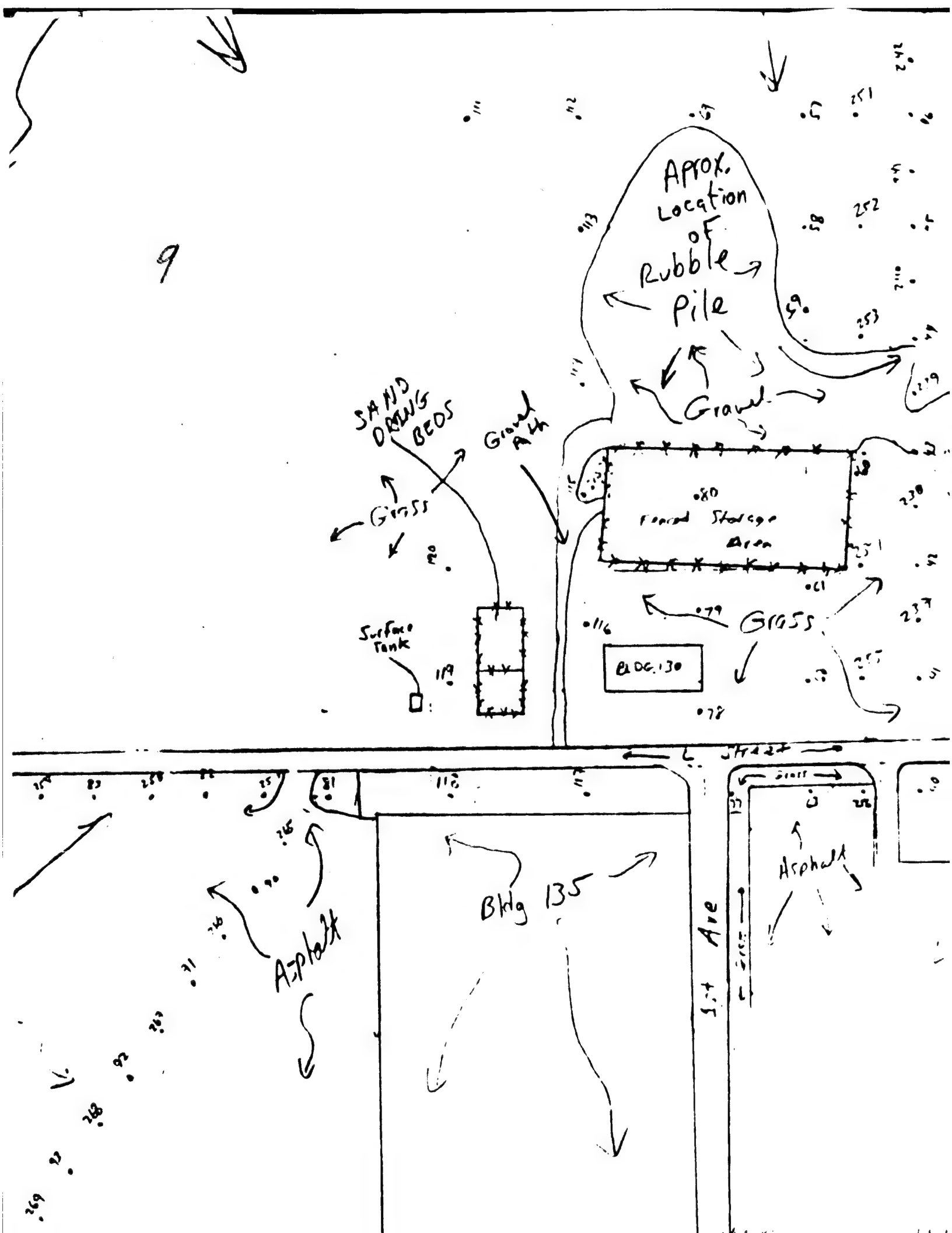
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APPROX.  
Location  
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Jibble  
Pile

Gravel

Storage  
Area

GRASS

30

078

1st Street

1st Ave

Asphalt

Asphalt

BLDG 147

Maintenance Bldg

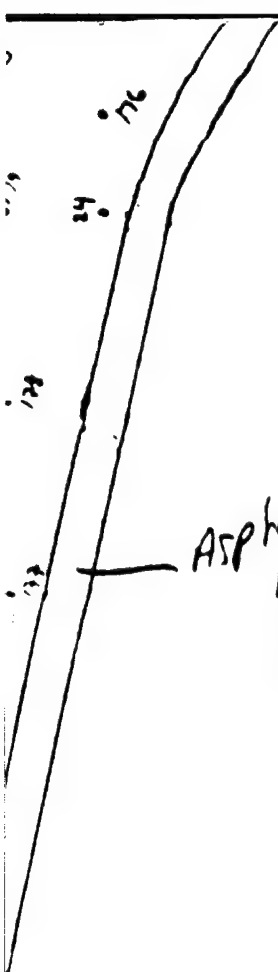
Grass

GRASS

Asphalt  
Rd  
(2nd Ave)

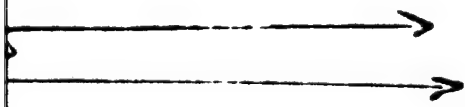
GRASS

2nd Avenue



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Asphalt  
Rd  
(2nd Ave)



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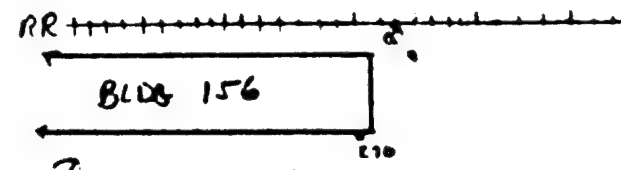
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NUMBER	DATE	MADE BY	CHECKED BY	DESCRIPTION
REVISIONS				

Grass  
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Asphalt  
269  
22  
268  
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Asphalt  
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AGGREGATE  
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Asphalt

Bldg 135

1st Ave

15

156

Asphalt

**M&E**

**Metcalf & I**

REG. PROF. ENGR.



35

1st Ave

Asphalt

Asphalt

BUDG 147  
Maintenance Bldg

2nd Avenue

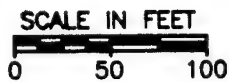
Gloss

RR

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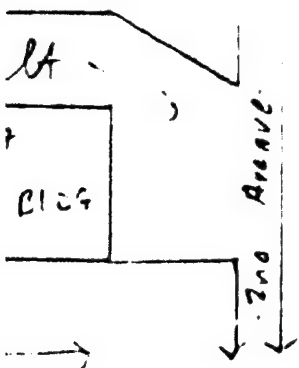
Metcalf & Eddy

SCALE: 1" = 100'



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SCALE IN FEET  
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LEXINGTON BLUEGRASS ARMY DEPOT

# PHASE 3 SOIL GAS FIELD MAP

LEXINGTON, KENTUCKY

ED OR CHANGED BY REPRODUCTION

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N BLUEGRASS ARMY DEPOT

# SOIL GAS FIELD MAP

XINGTON, KENTUCKY

JOB 012308-0006

FILE NO. 308-TLE

FIGURE 2-3

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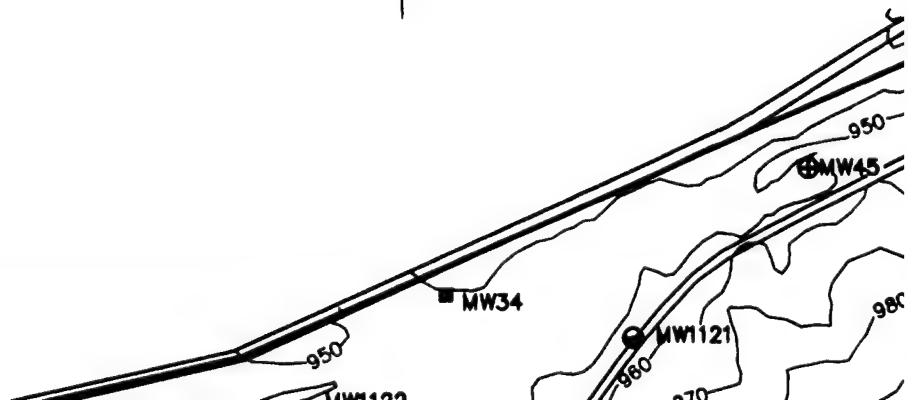
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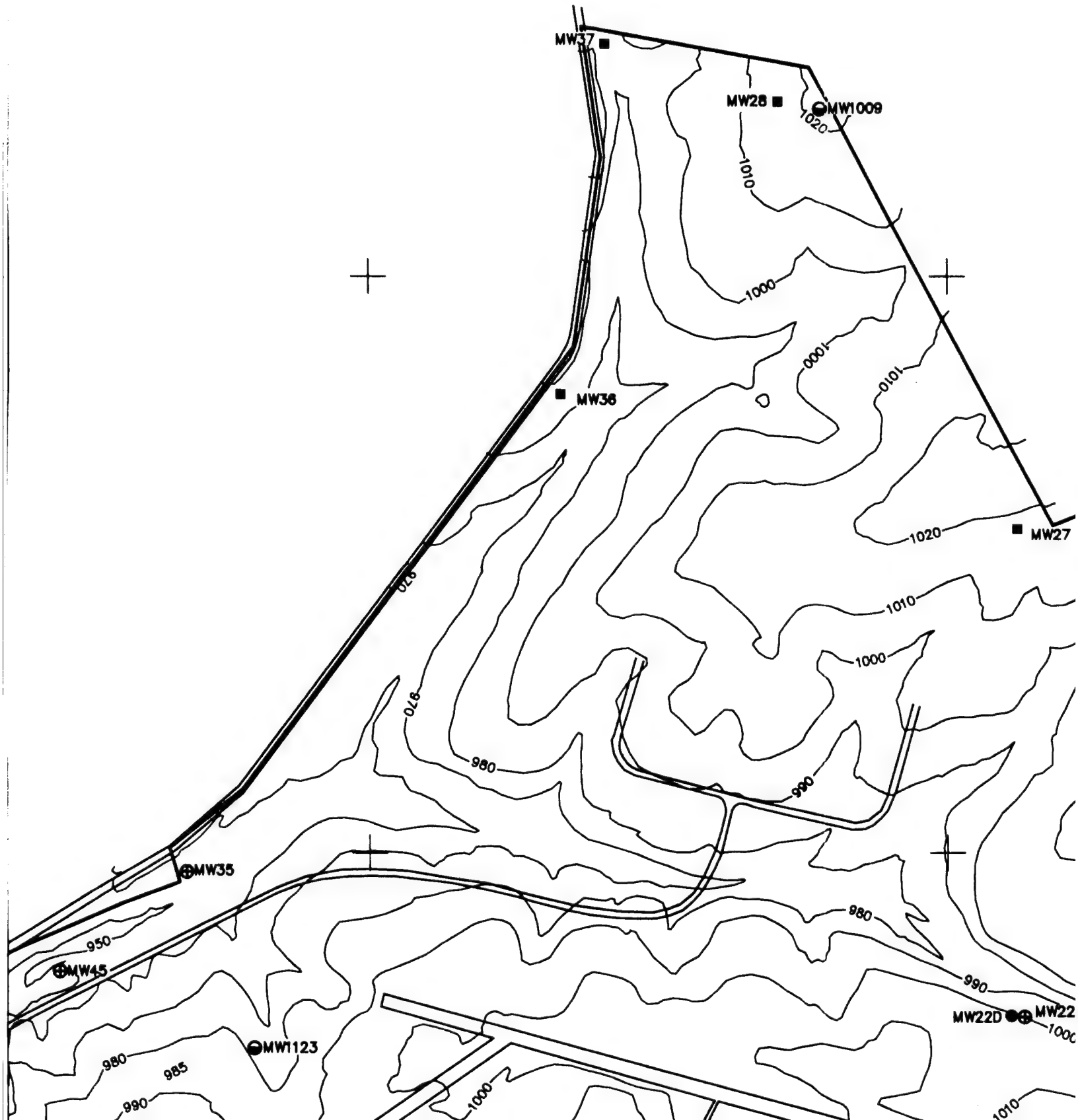
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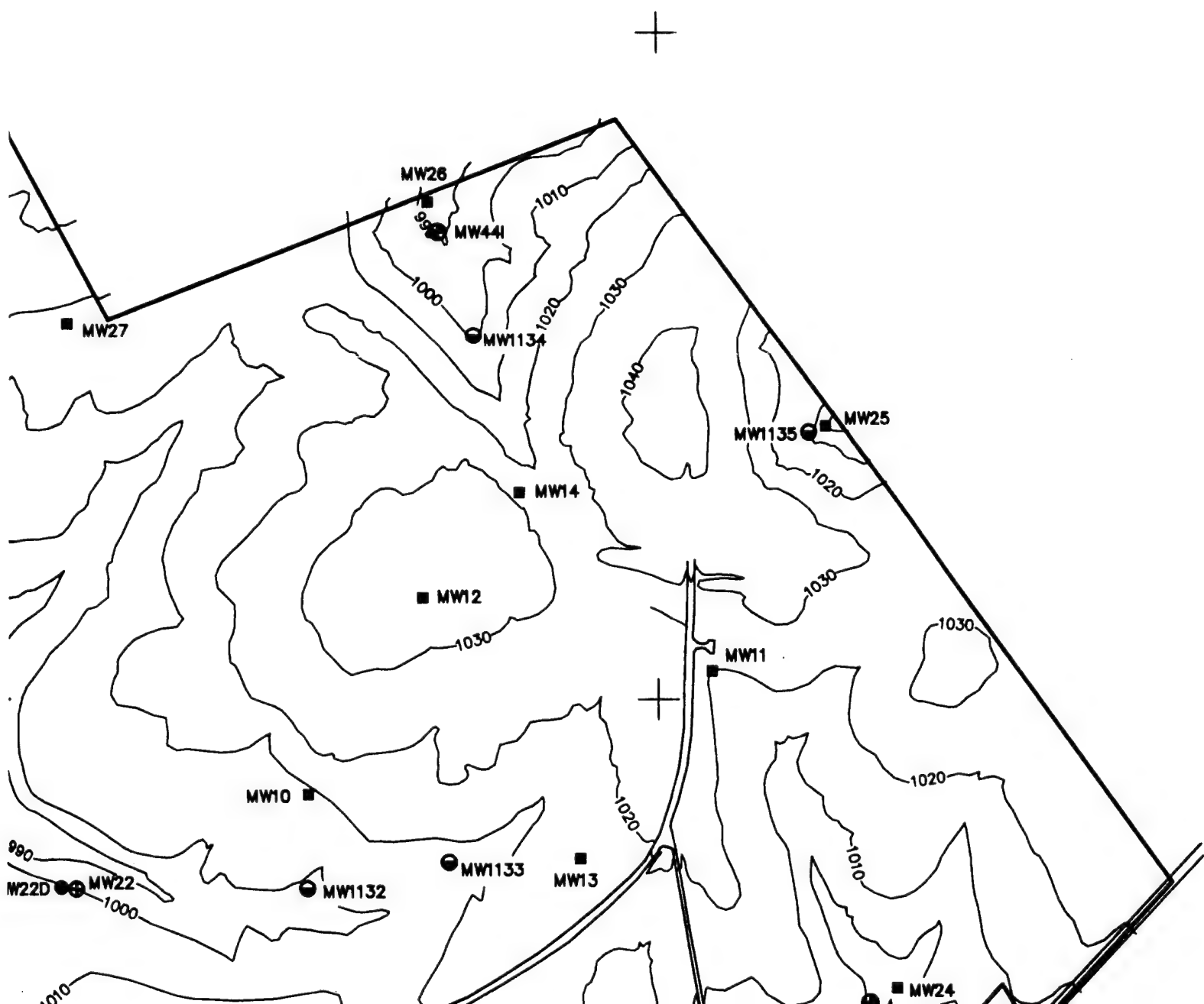
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MW24



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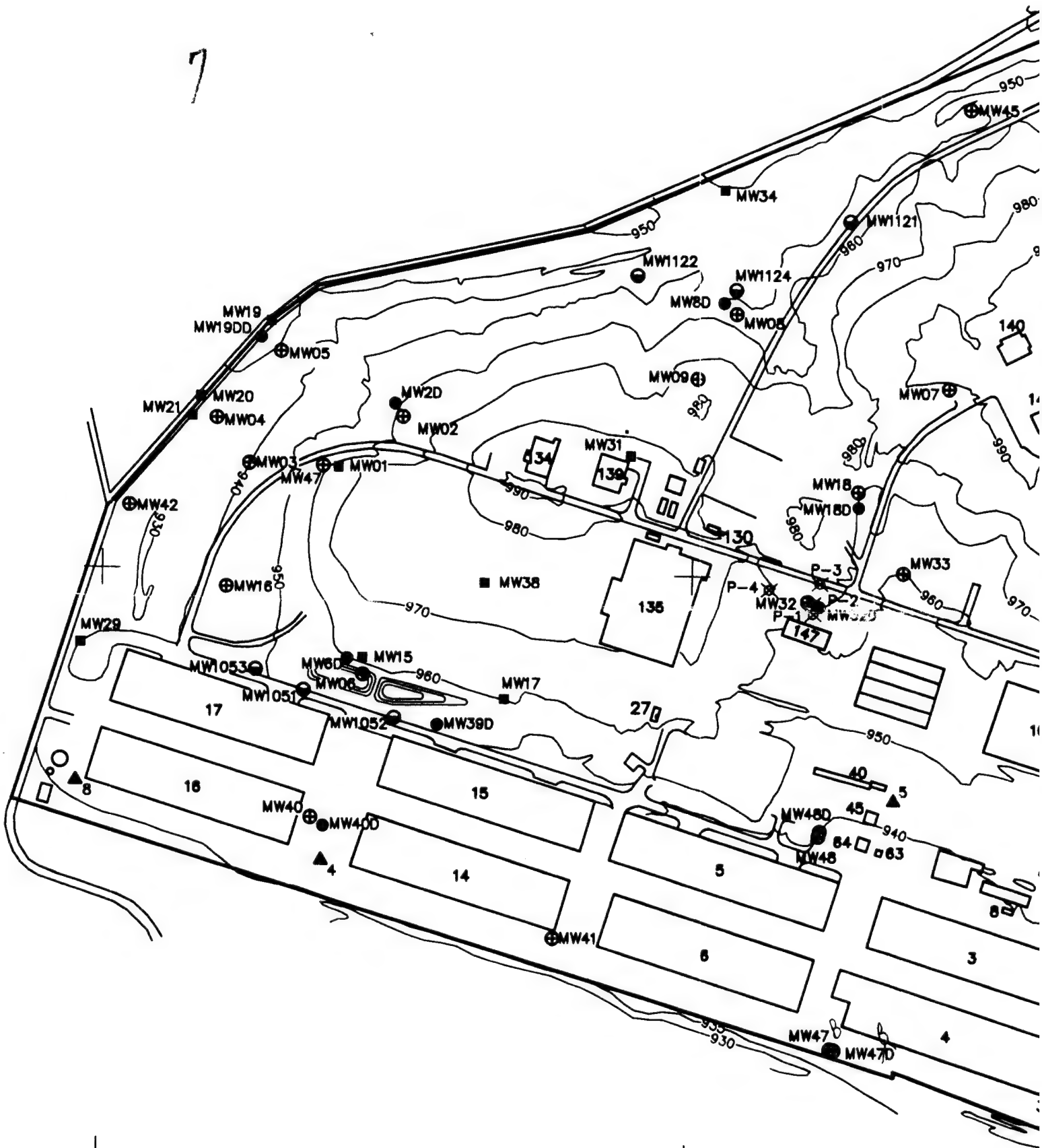
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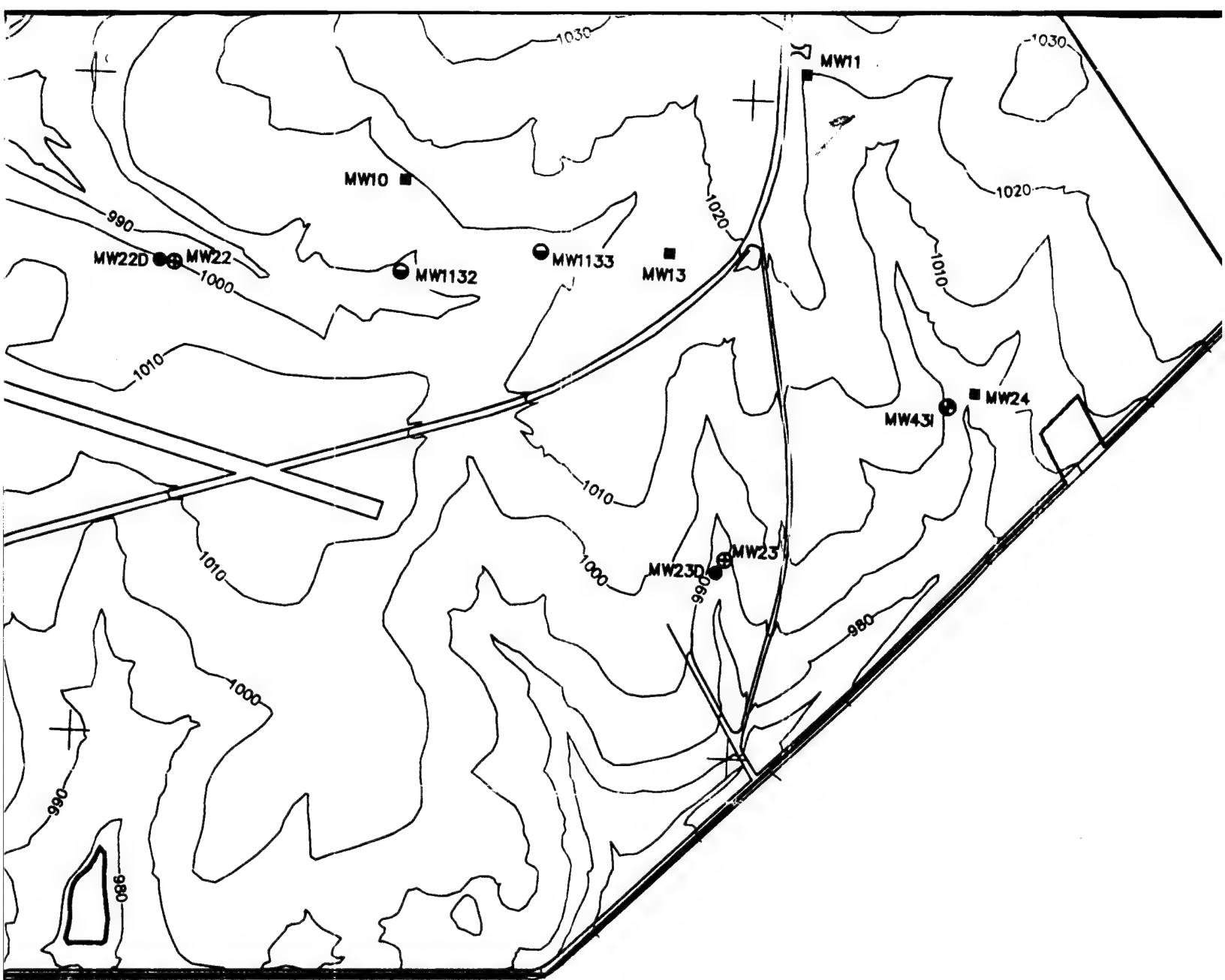
### LEGEND

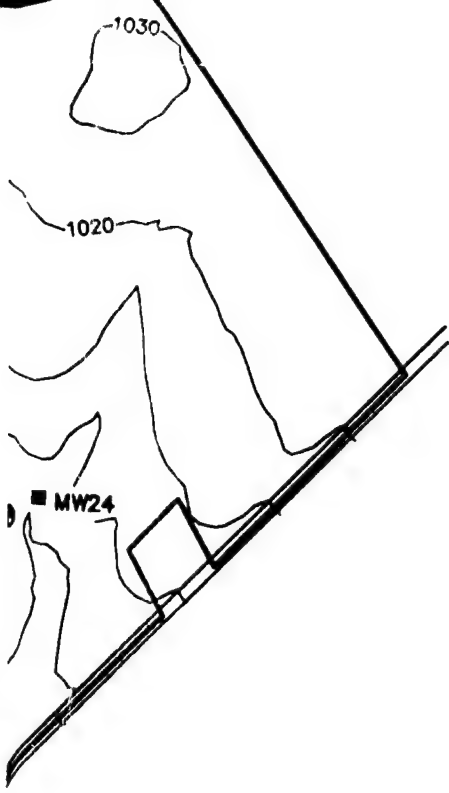
- DRY HOLES
- EXISTING WELLS
- ⊕ SHALLOW WELLS
- DEEP WELLS
- BEDROCK INTERFACE

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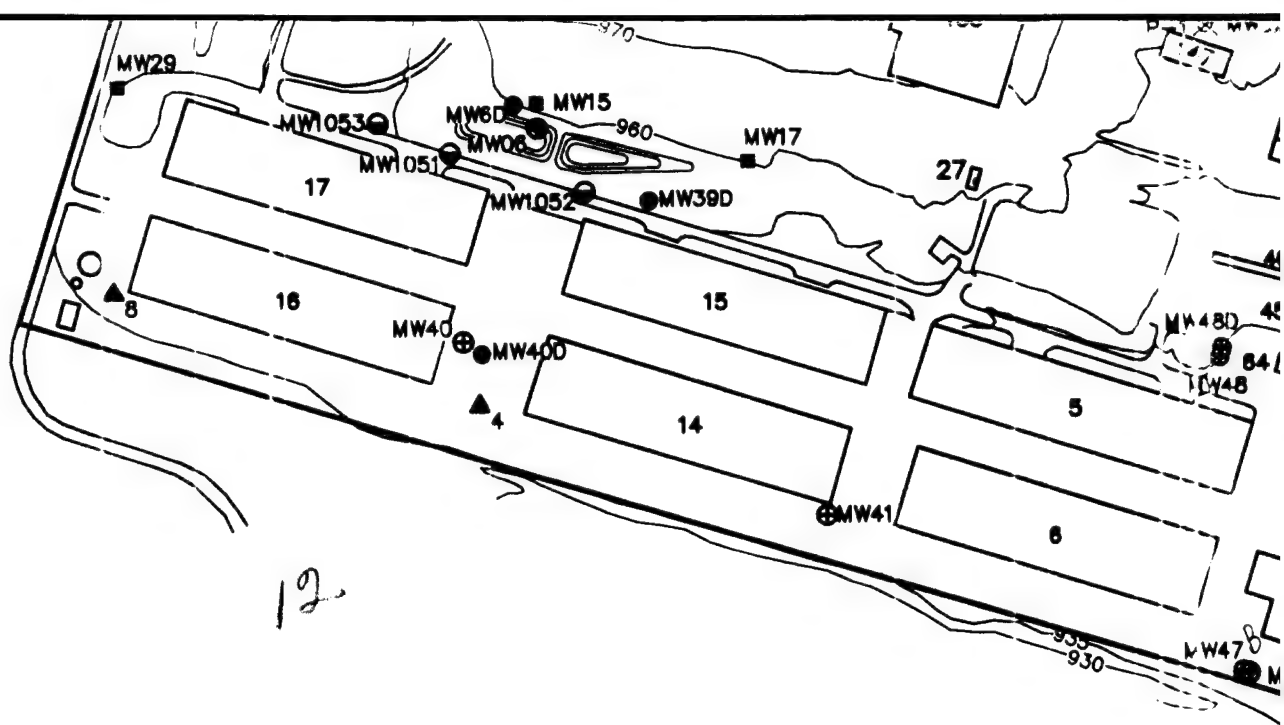
### LEGEND

- DRY HOLES
- EXISTING WELLS
- ⊕ SHALLOW WELLS
- DEEP WELLS
- ⊙ BEDROCK INTERFACE WELL
- ▲ PRODUCTION WELL
- ⊗ PIEZOMETER

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NUMBER	DATE	MADE BY	CHECKED BY	DESCRIPTION

REVISIONS



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WELLS

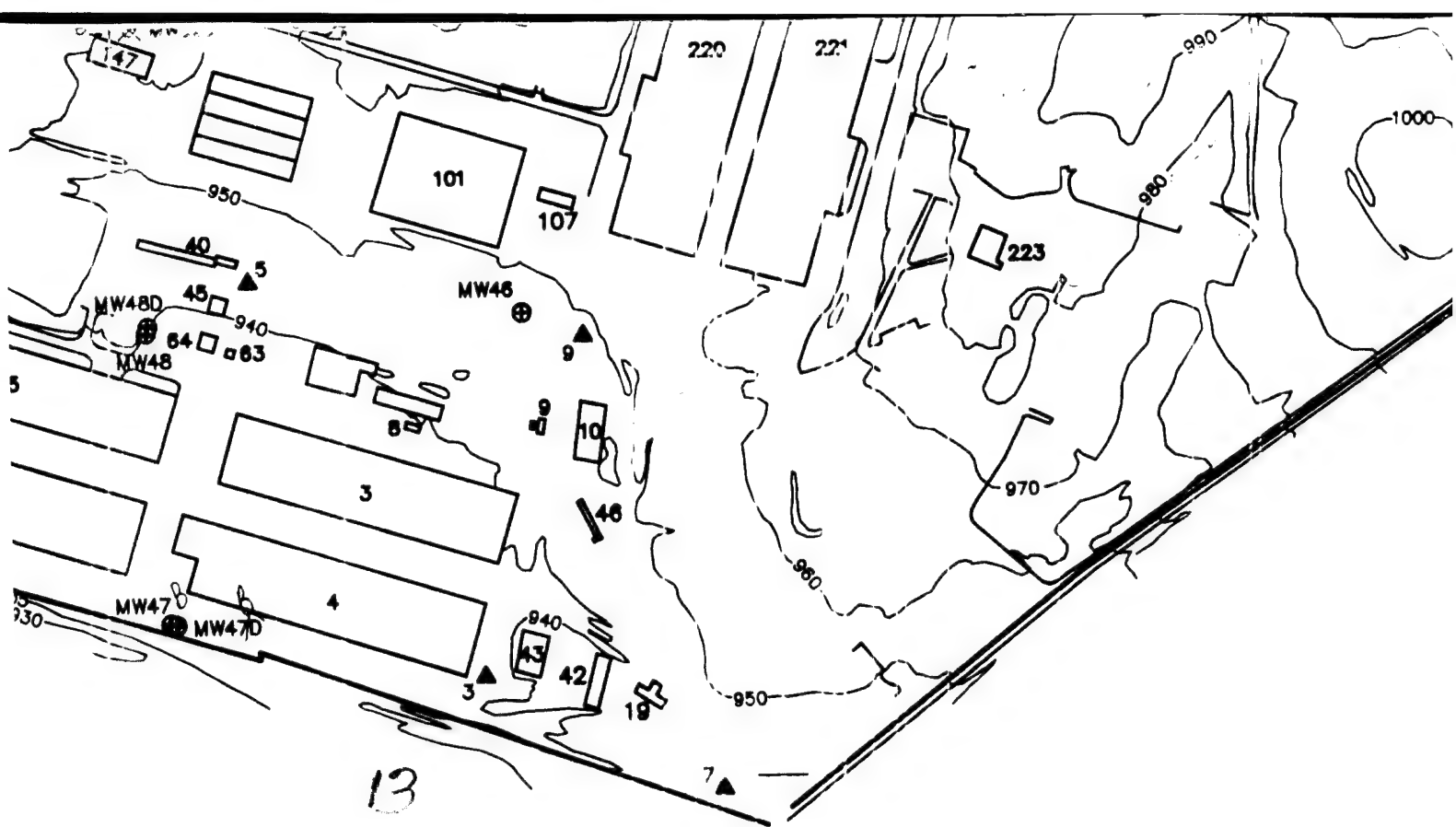
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	DEPT. CHECK	
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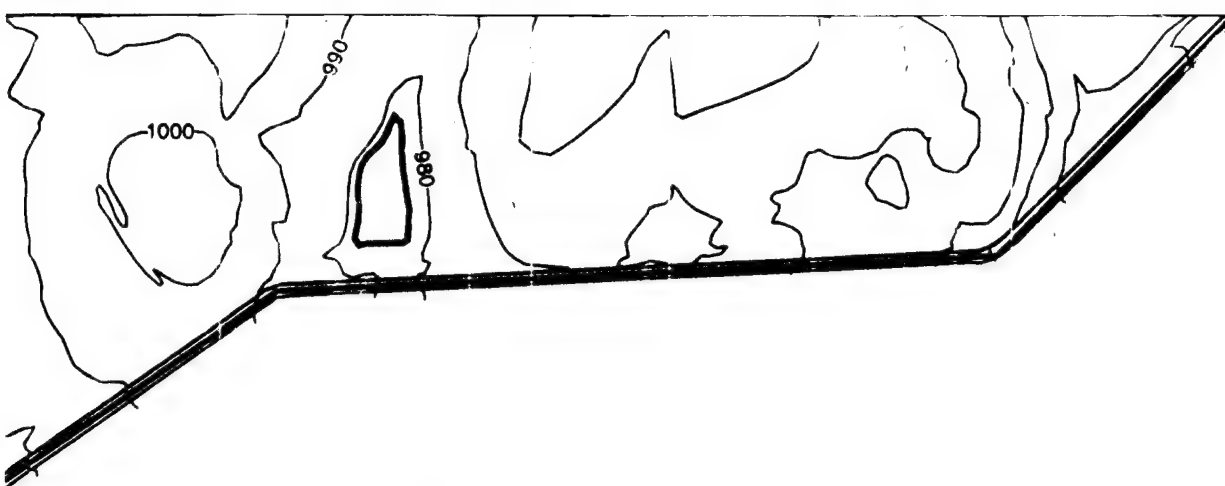


**M&E** Metcalf & Eddy

REG. PROF. ENGR.

DATE





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SCALE: 1" = 437.44'



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MONITOR WELL & I  
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LEXINGTON BLUEGRASS ARMY DEPOT

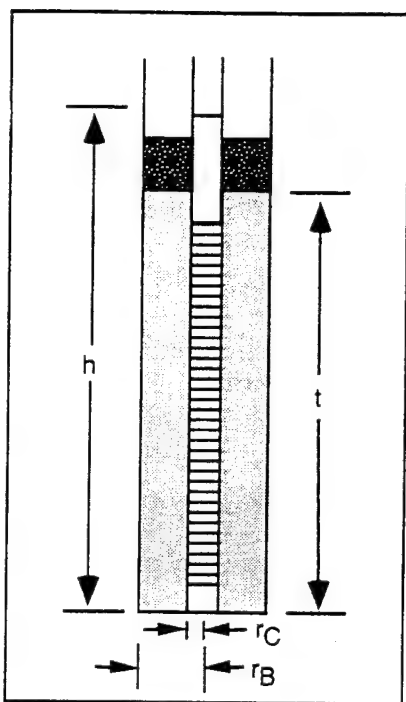
JOB 012308

FILE NO. 308-2-4

DR WELL & DRY HOLE LOCATIONS

LEXINGTON, KENTUCKY

FIGURE 2-4



		Symbol
Depth to water from TOC	_____ ft.	D
Total Depth of well from TOC	_____ ft.	TD
Height of Water column in well	_____ ft.	TD- D=h
Top of sand pack	_____ ft.	TSP
Bottom of well screen	_____ ft.	BWS
Thickness of sand pack	_____ ft.	BWS-TSP=t
Radius of borehole	_____ ft.	$r_B$
Radius of casing	_____ ft.	$r_C$
Assumed porosity of sand pack	_____ ft.	n (20-30%typ.)

#### Volume Calculations

Volume of Water in Casing,  $V_C$ :

$$\begin{aligned}
 V_C &= 0.163 \times r_C^2 \times h \\
 &= 0.163 \times (\text{_____ in.})^2 \times \text{_____ ft.} \\
 &= \text{_____ gallons}
 \end{aligned}$$

Volume of Borehole,  $V_B$ :

$$\begin{aligned}
 V_B &= 0.163 \times r_B^2 \times t \text{ (t or h, whichever is less)} \\
 &= 0.163 \times (\text{_____ in.})^2 \times \text{_____ ft.} \\
 &= \text{_____ gallons}
 \end{aligned}$$

Volume in Annular Space:

$$\begin{aligned}
 V_A &= (V_B - V_C)n \\
 &= (\text{_____ gallons} - \text{_____ gallons}) \times n \\
 &= \text{_____ gallons}
 \end{aligned}$$

Total Volume to be removed (if five borehole volumes):

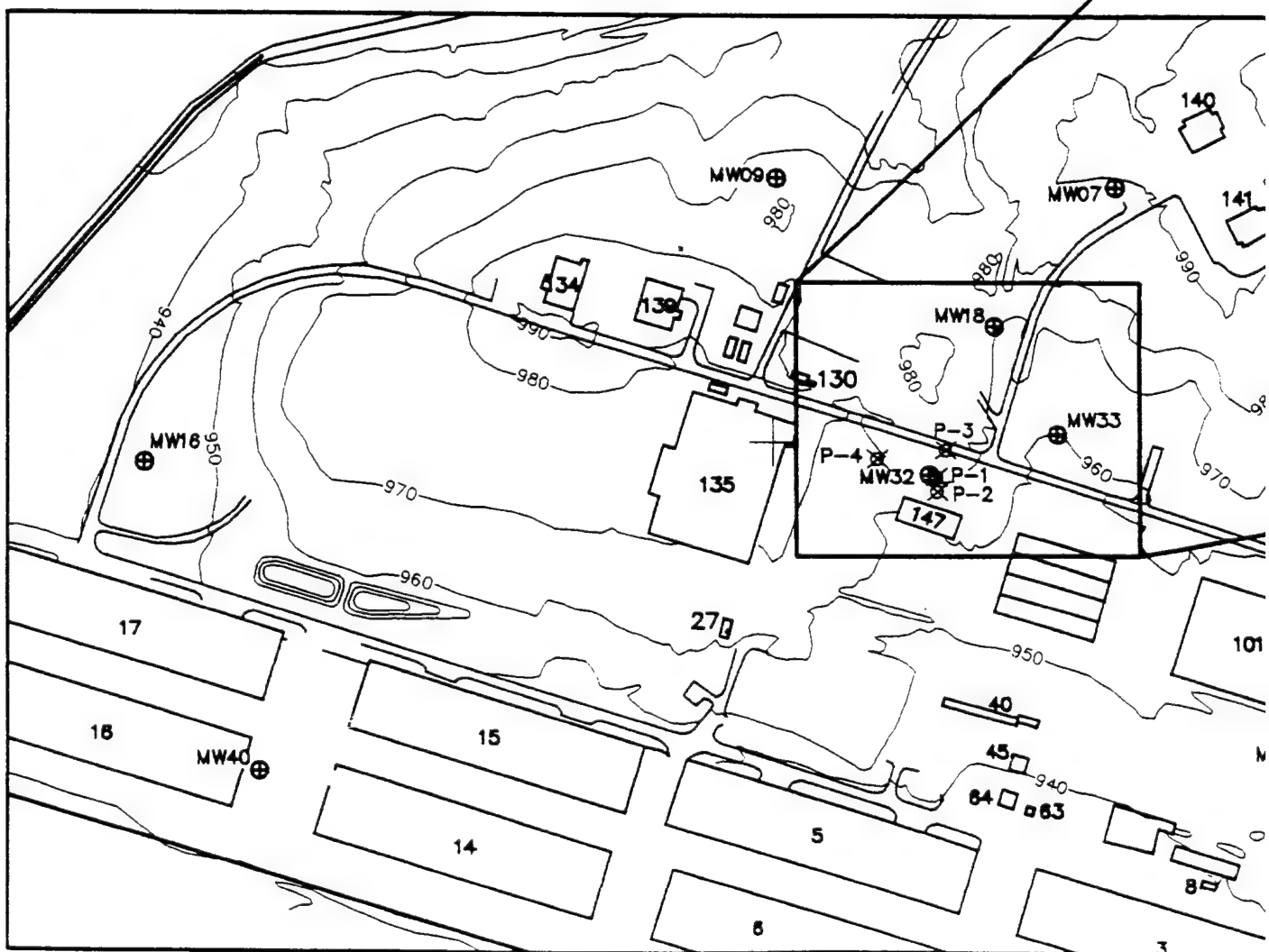
$$\begin{aligned}
 V_R &= 5 (V_C + V_A) \\
 &= 5 (\text{_____ gallons} + \text{_____ gallons}) \\
 &= 5 (\text{_____ gallons}) \\
 &= \text{_____ gallons to be removed for 5 borehole volumes prior to sampling}
 \end{aligned}$$

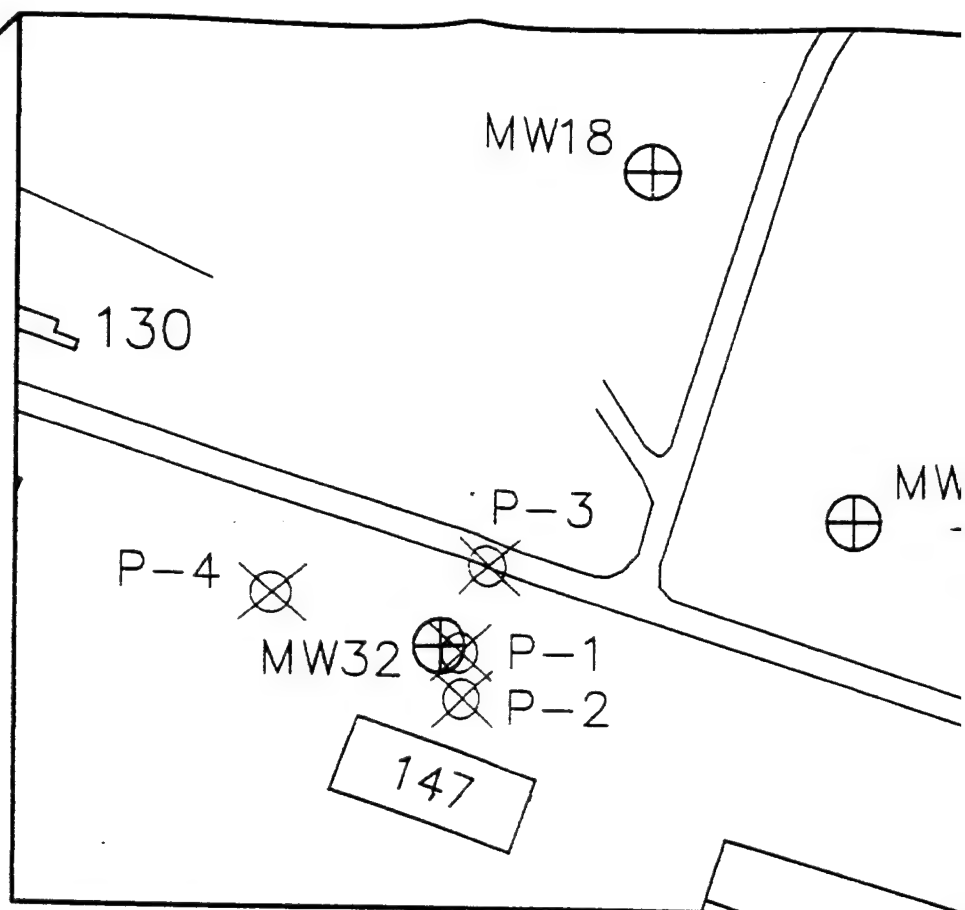
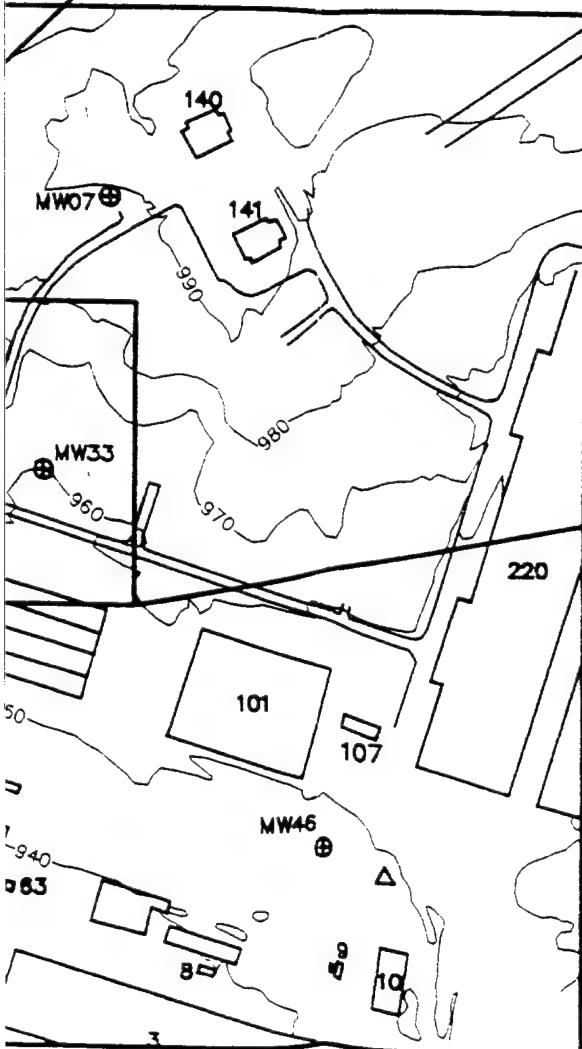


Lexington Blue-Grass Army Depot  
Calculation of Borehole Volumes  
for Monitor Well Development and Sampling

Project Number  
012308

Figure  
2-5





# **LEGEND**

- P-4 X PIEZOMETERS—MONITORED
- MW40 ⊕ WELLS MONITORED
- P-2 PUMPING WELL

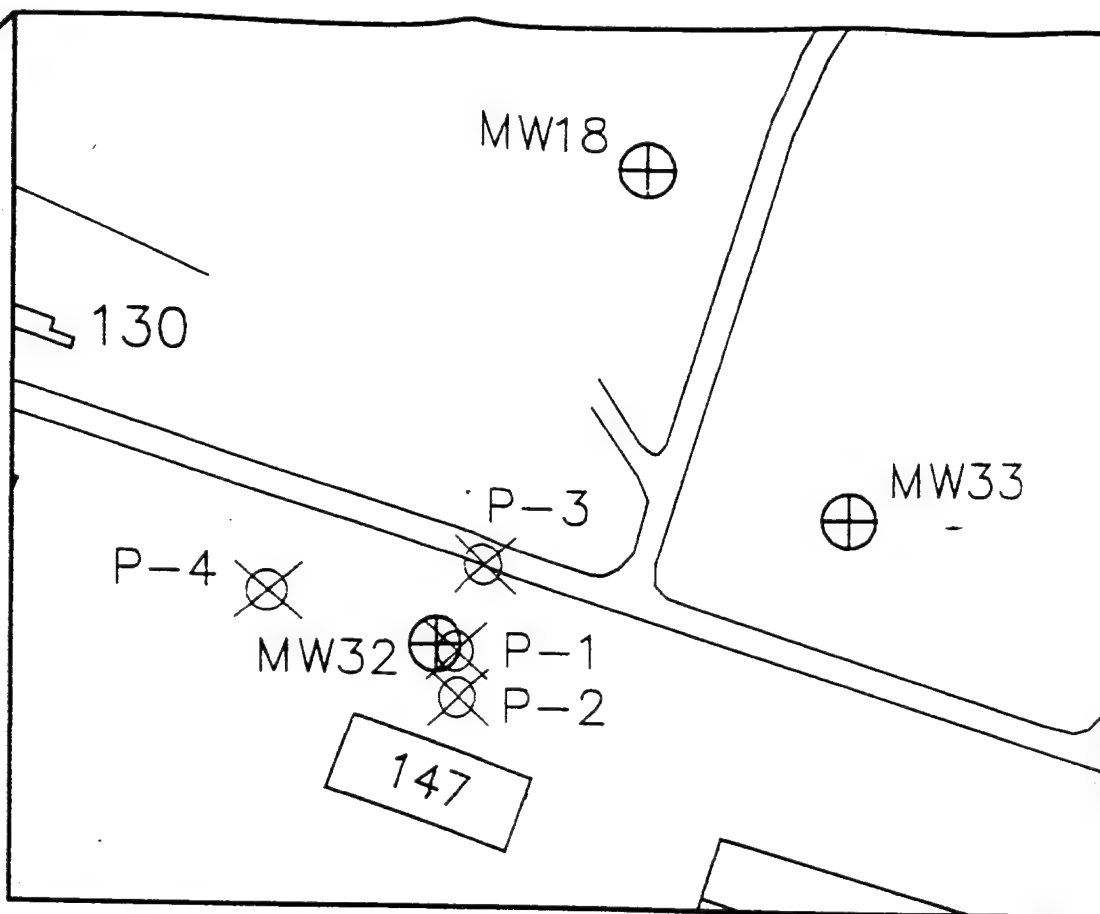
**M&E Metcalf & E**

LEXINGTON BLUEGRASS ARMY D

PUMPING TEST WELL LOC

LEXINGTON, KENTUCKY

FILE NAME	CHECKED	DRAWN	DATE	PROJECT
308-1-6		CAP/TPF	AUG 95	01230



SCALE IN FEET  
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**LEGEND**

- P-4 X PIEZOMETERS-MONITORED  
MW40 ⊕ WELLS MONITORED  
P-2 PUMPING WELL



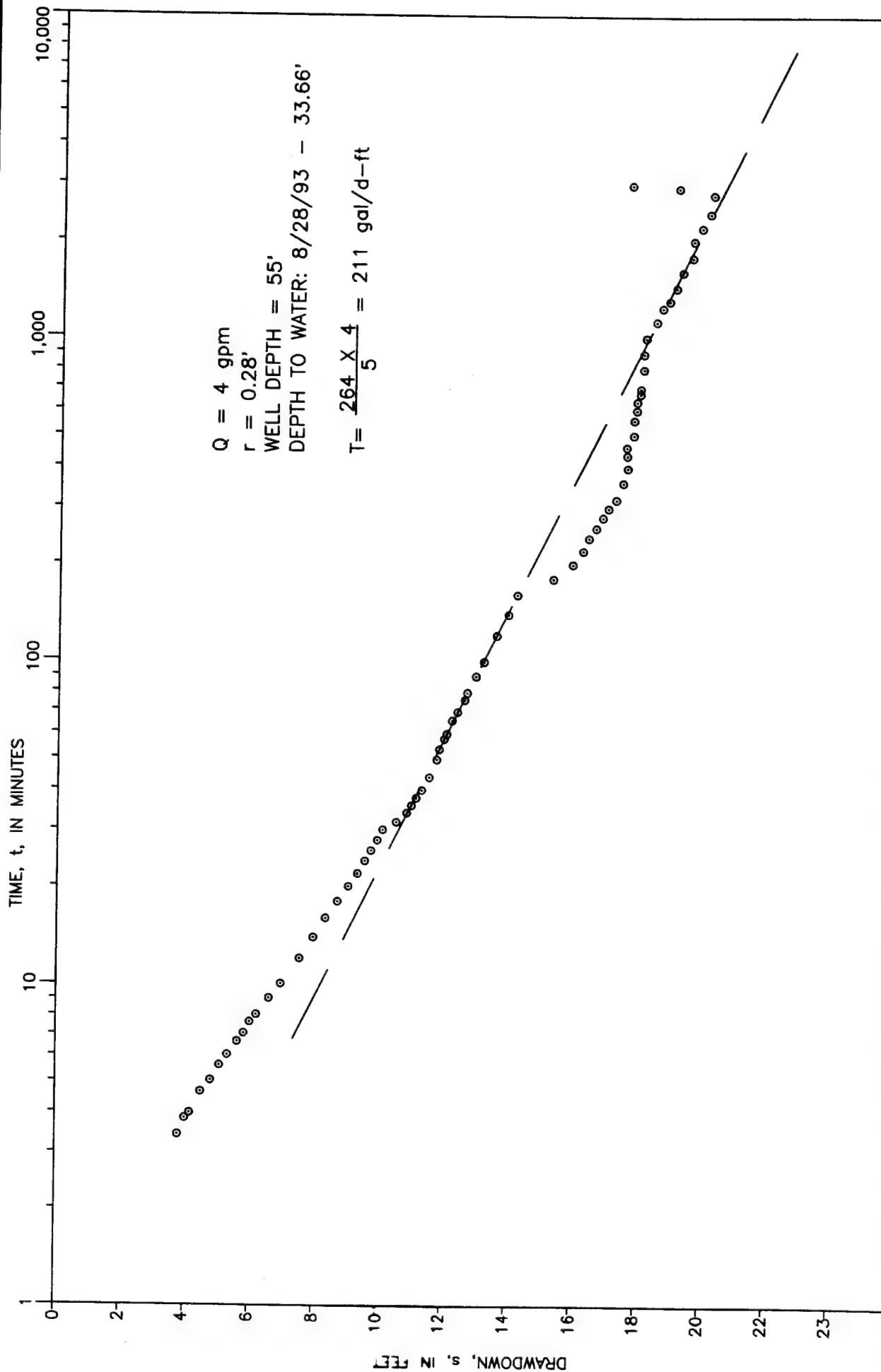
**Metcalf & Eddy**

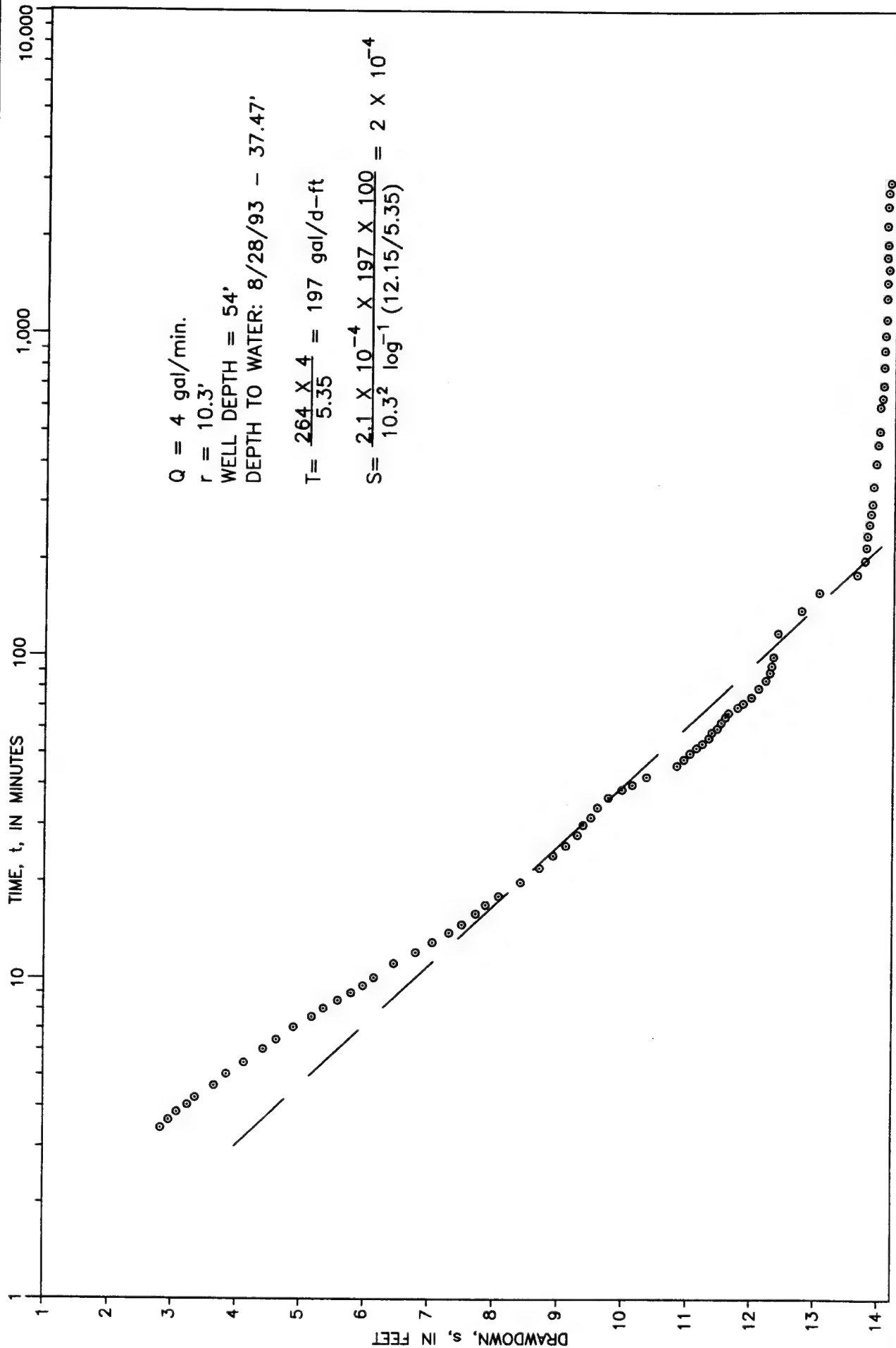
LEXINGTON BLUEGRASS ARMY DEPOT

**PUMPING TEST WELL LOCATIONS**

LEXINGTON, KENTUCKY

FILE NAME	CHECKED	DRAWN	DATE	PROJECT NO.	FIGURE
308-2-6		CAP/TPF	AUG 95	012308	2-6

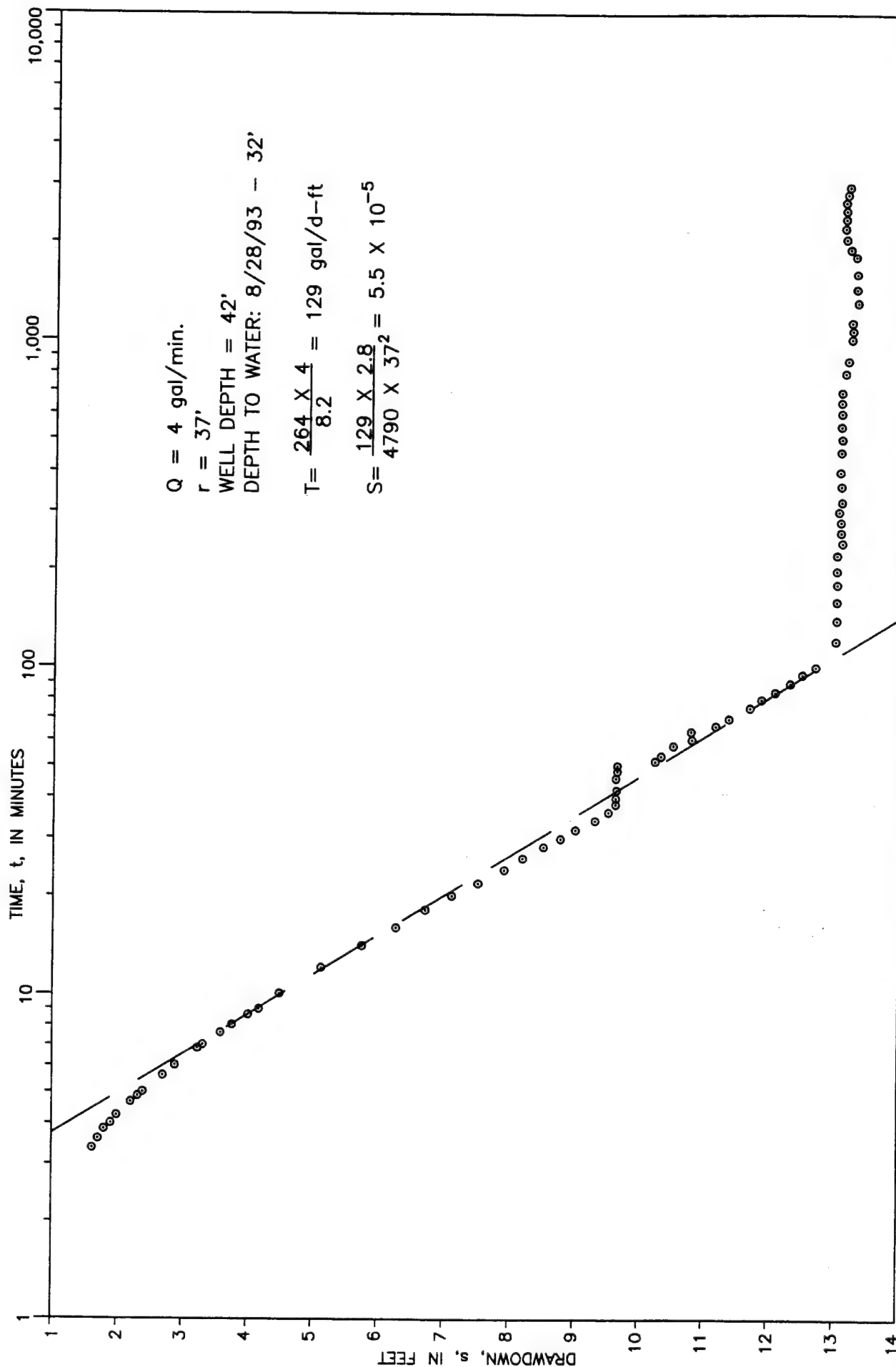




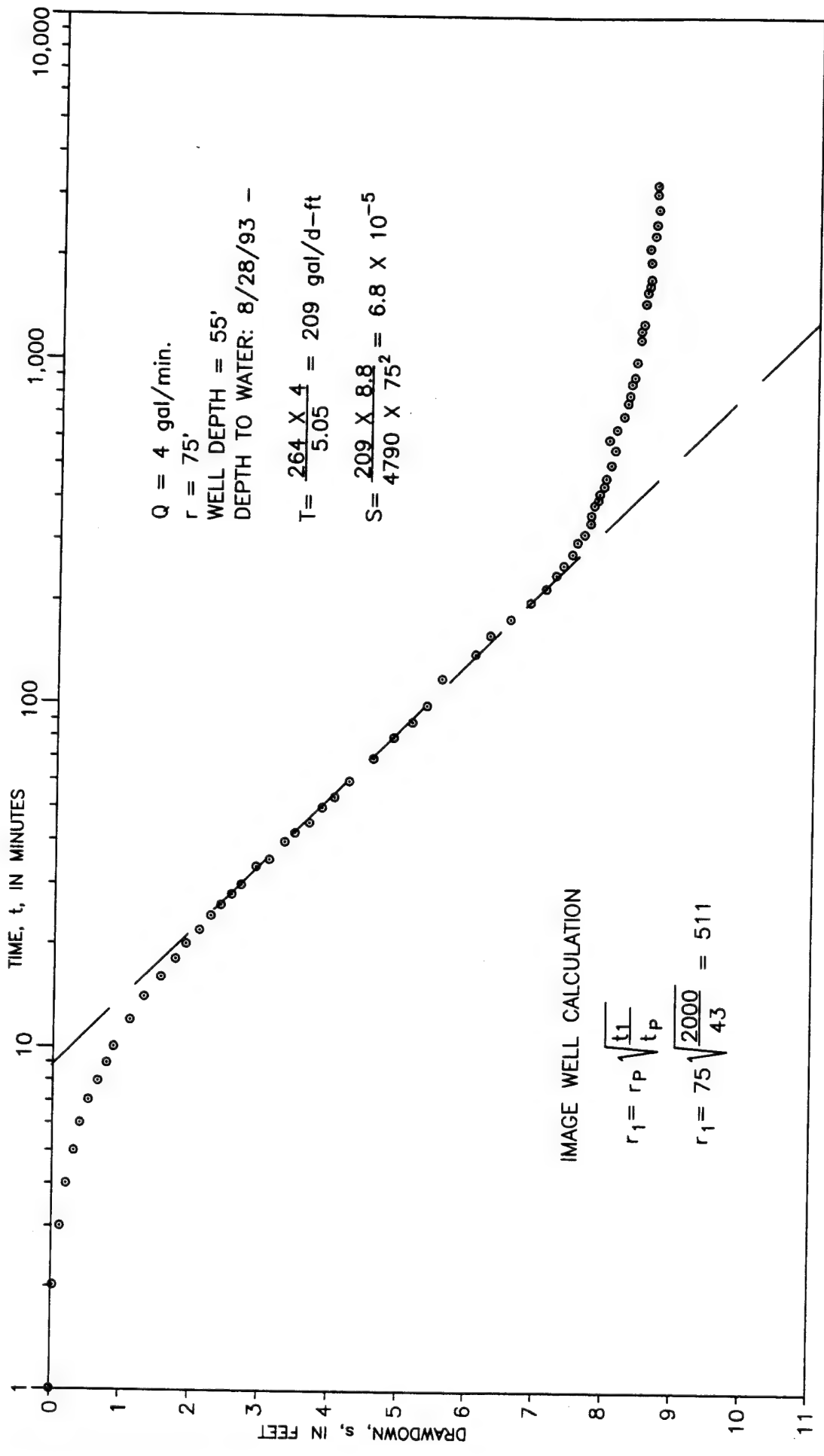
# LEXINGTON BLUEGRASS ARMY DEPOT DRAWDOWN VS. TIME IN WELL MW-32

LEXINGTON, KENTUCKY



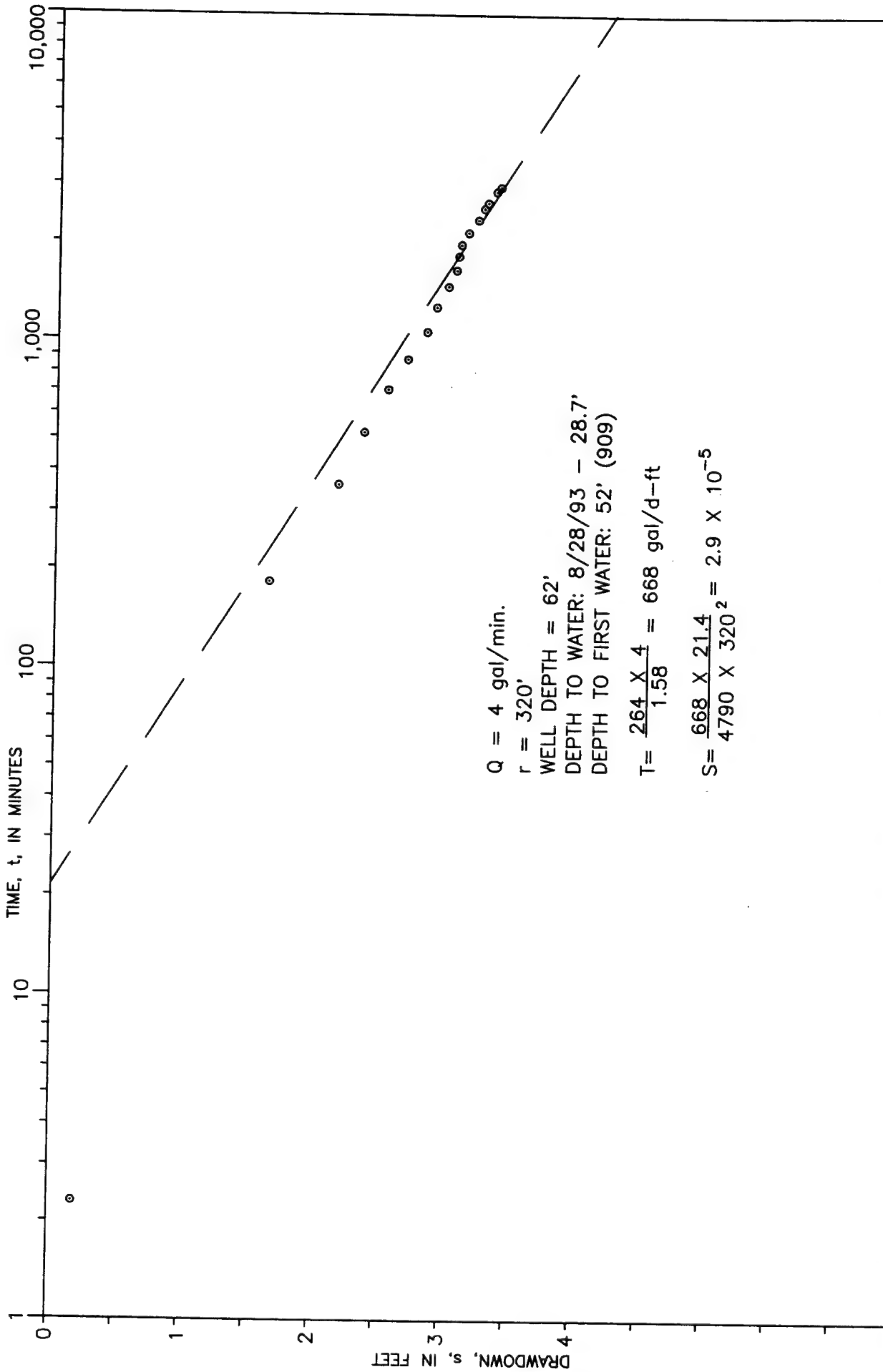


LEXINGTON BLUEGRASS ARMY DEPOT  
**DRAWDOWN VS. TIME IN WELL P2**  
 LEXINGTON, KENTUCKY



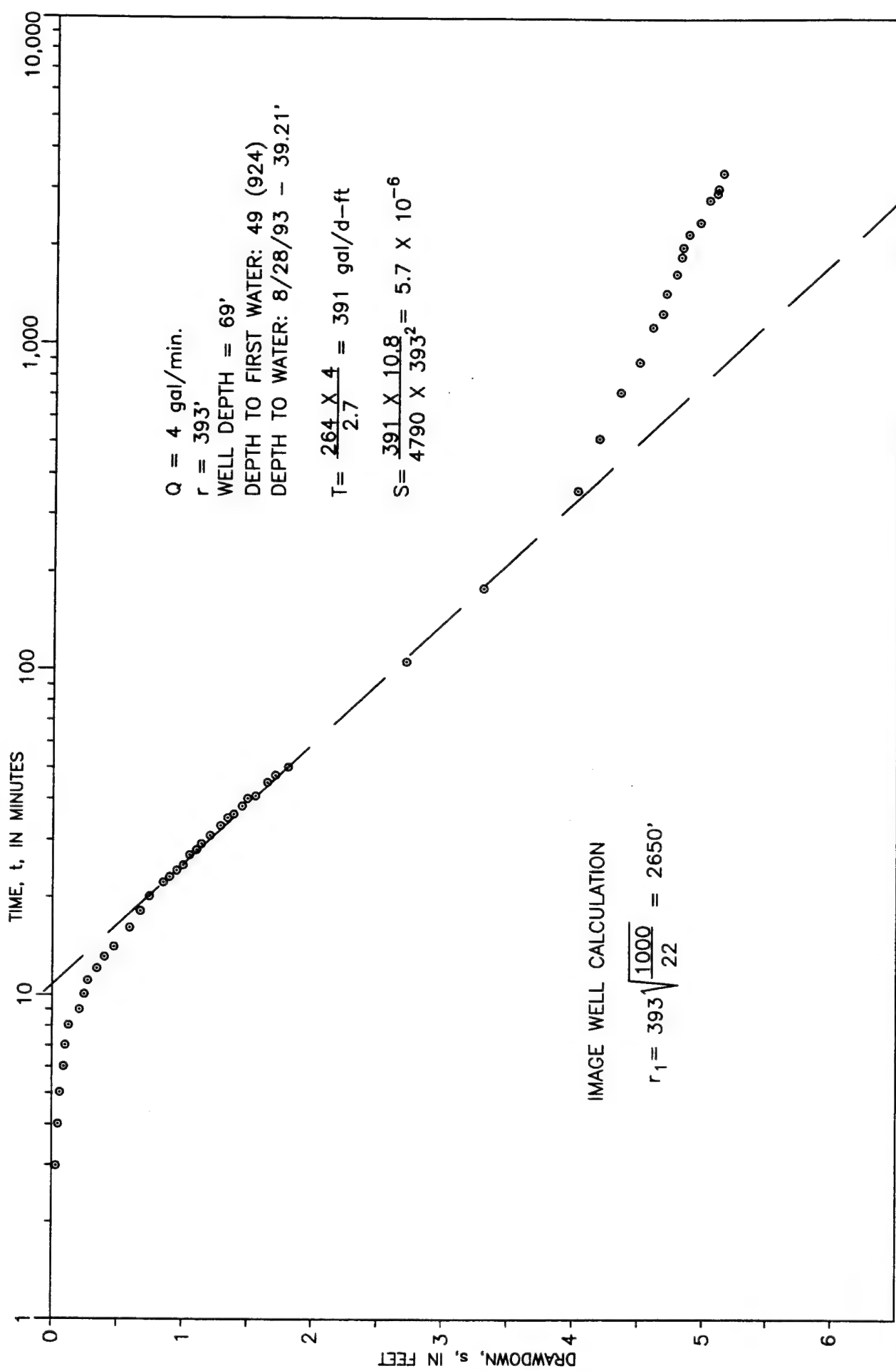
LEXINGTON BLUEGRASS ARMY DEPOT  
**DRAWDOWN VS. TIME IN WELL P3**  
 LEXINGTON, KENTUCKY

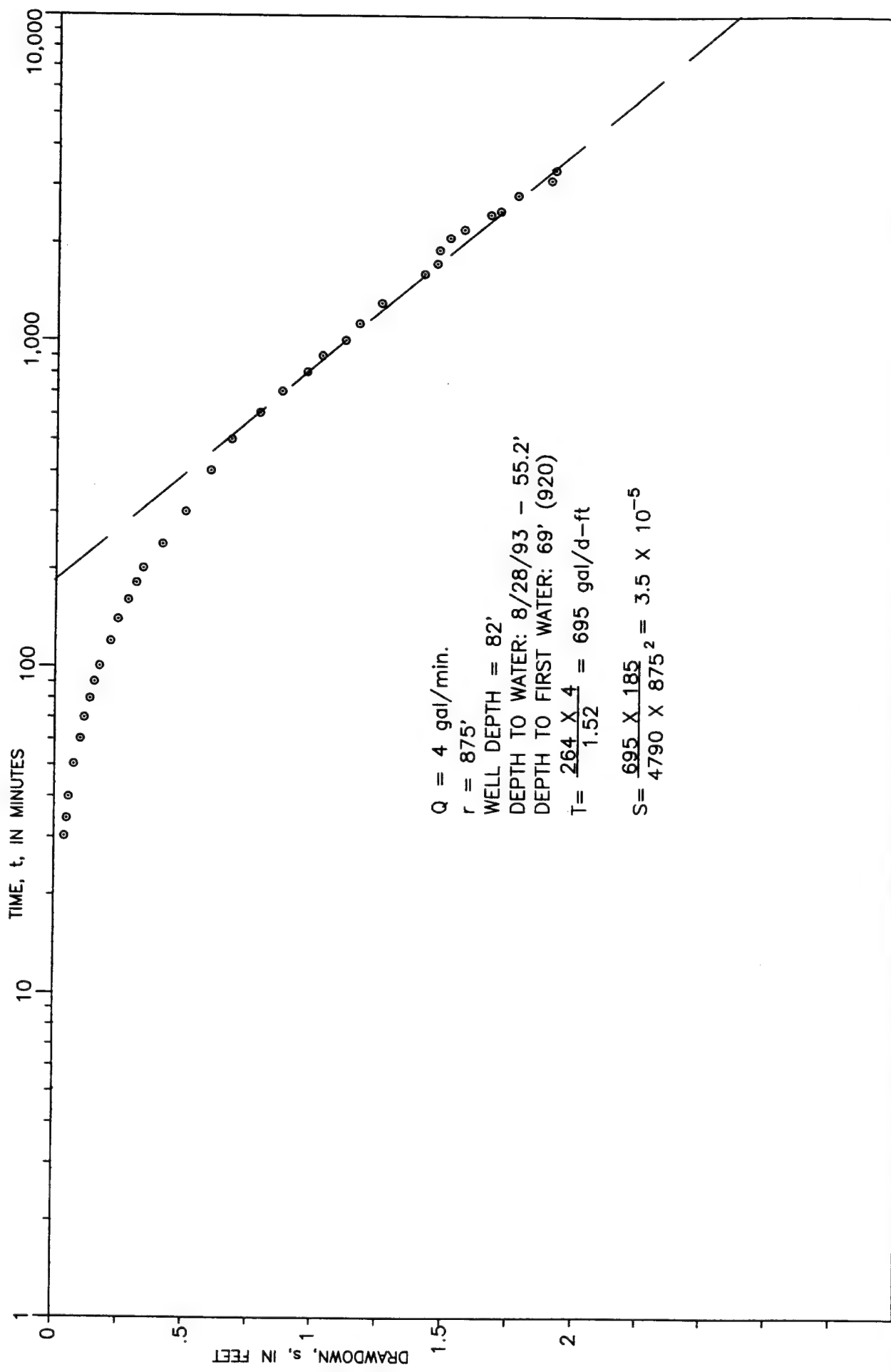
Project Number	
012308-0006	
File Name	Figure
TITLE	2-10



LEXINGTON BLUEGRASS ARMY DEPOT  
**DRAWDOWN vs. TIME IN WELL MW33**  
 LEXINGTON, KENTUCKY

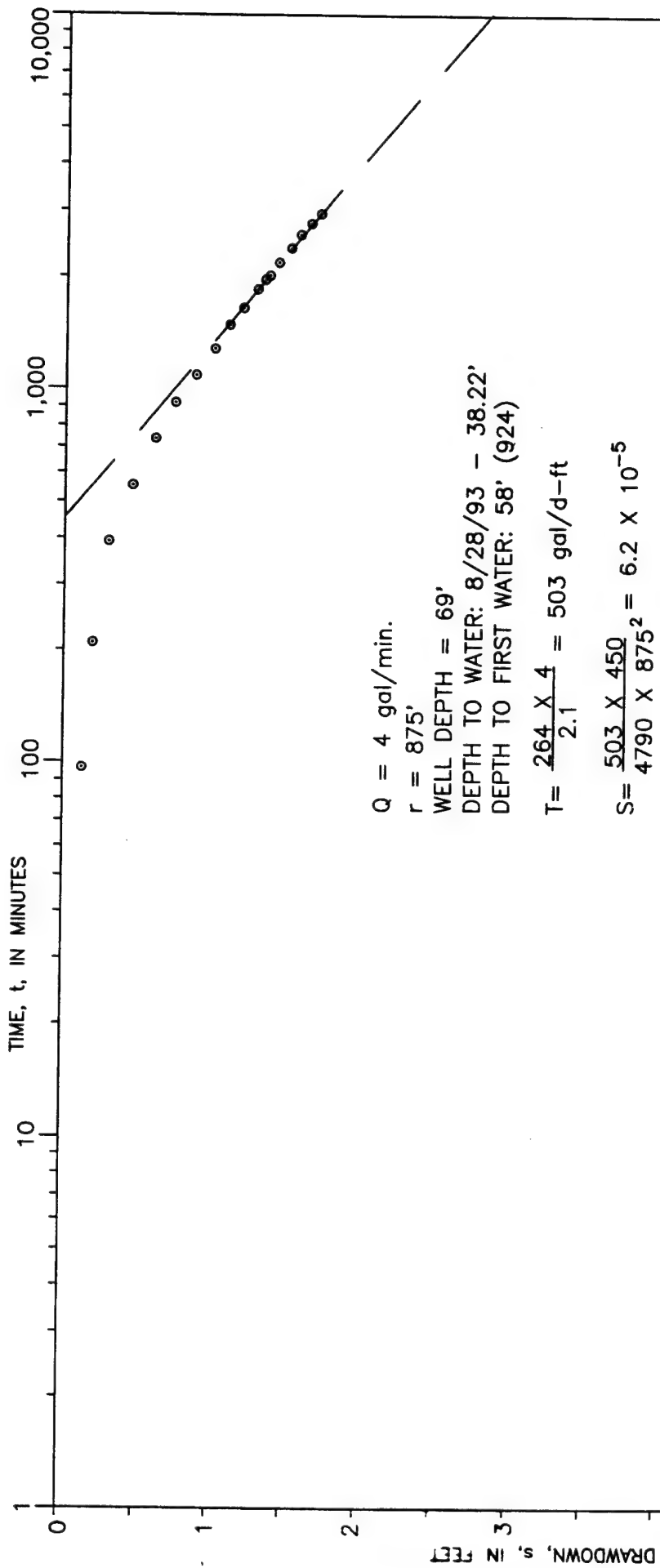
Project Number		012308-0006
File Name	Figure	TIME-1 2-11

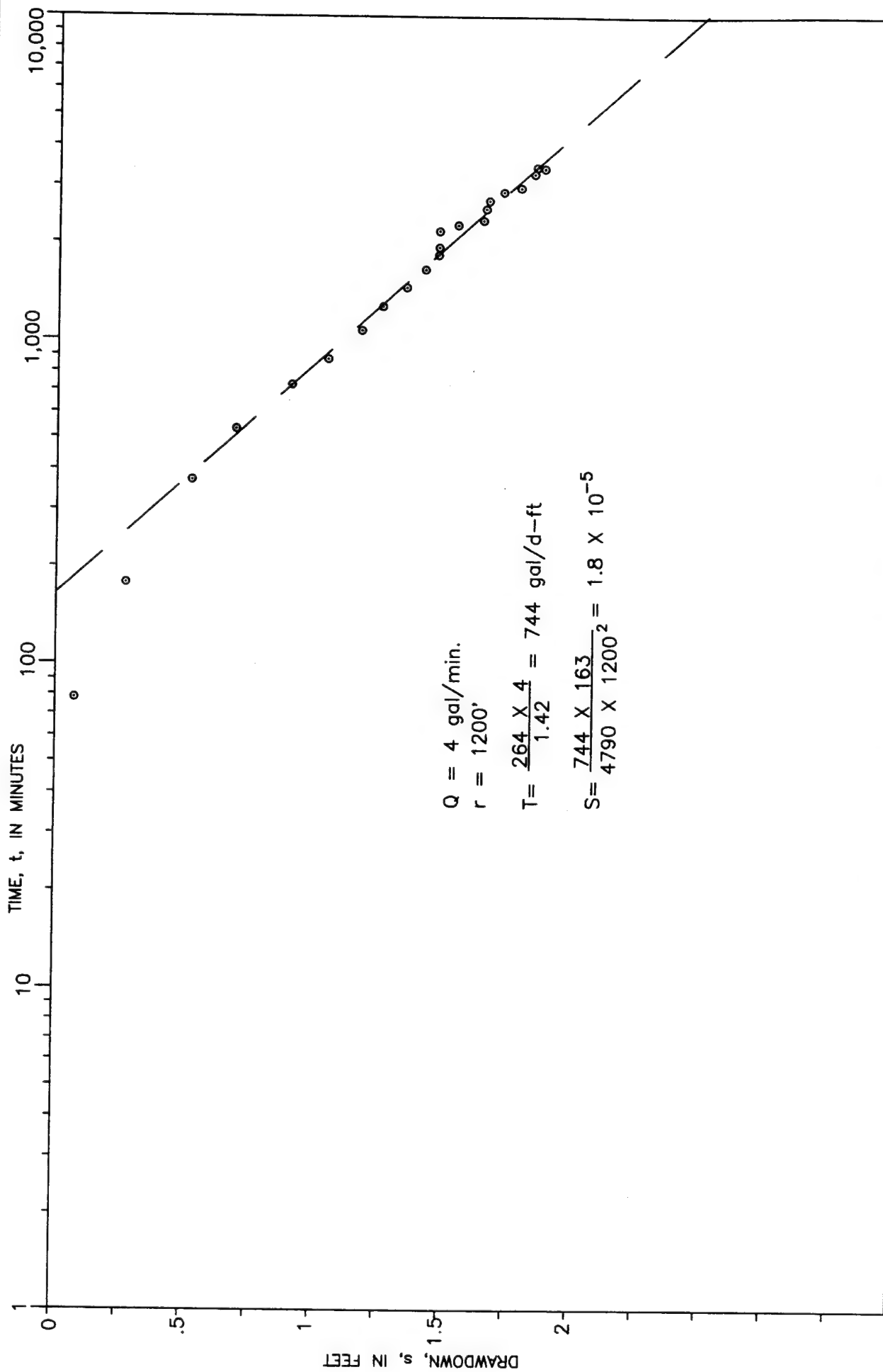




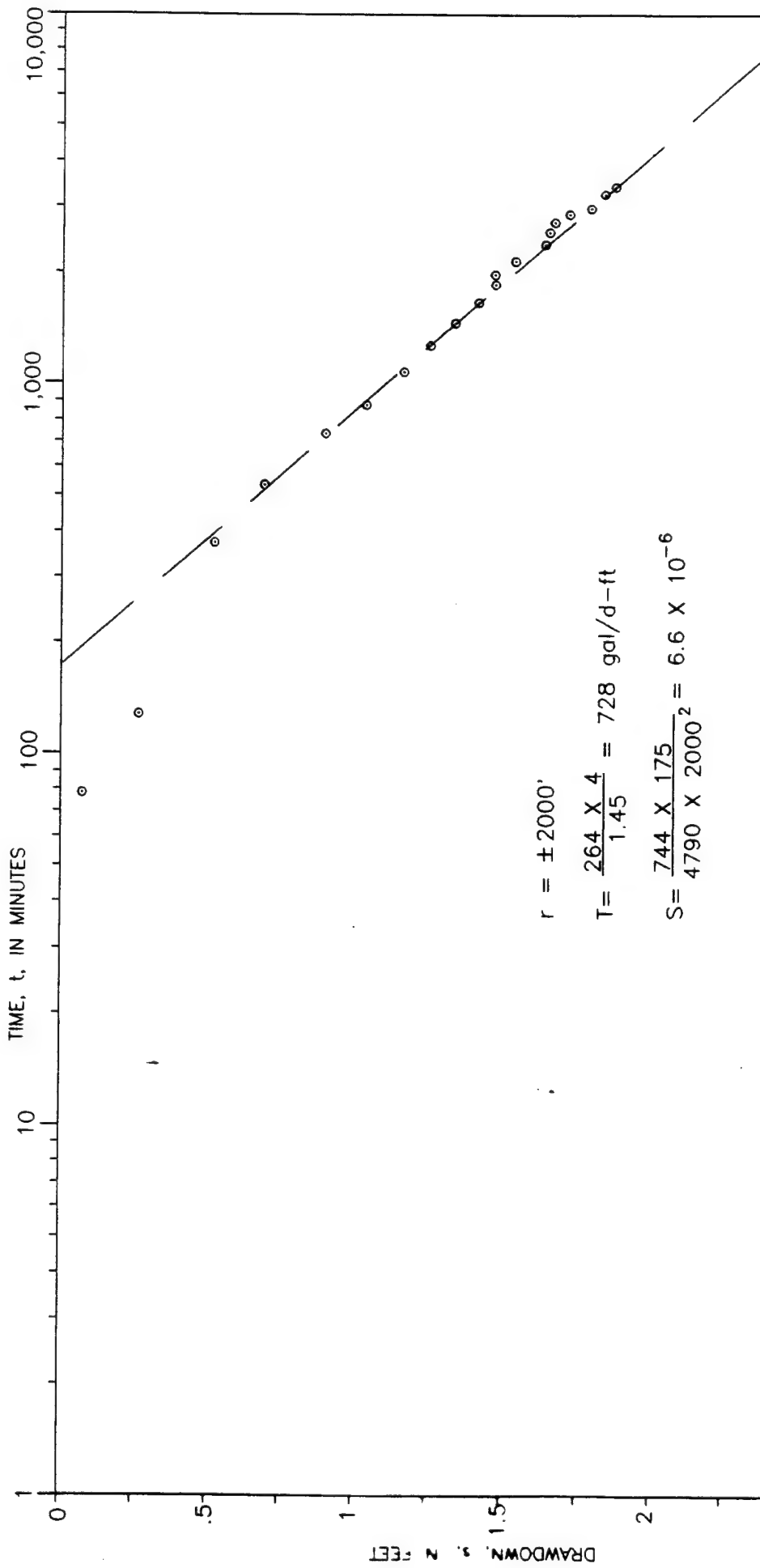
LEXINGTON BLUEGRASS ARMY DEPOT  
**DRAWDOWN VS. TIME IN WELL MW7**  
 LEXINGTON, KENTUCKY

Project Number		012308-0006
File Name	Figure	
TIME-1	2-13	





LEXINGTON BLUEGRASS ARMY DEPOT  
**DRAWDOWN VS. TIME IN WELL MW46**  
 LEXINGTON, KENTUCKY



LEXINGTON BLUEGRASS ARMY DEPOT

# DRAWDOWN VS. TIME IN WELL MW16

LEXINGTON, KENTUCKY

Project Number

012308-0006

File Name

TIME

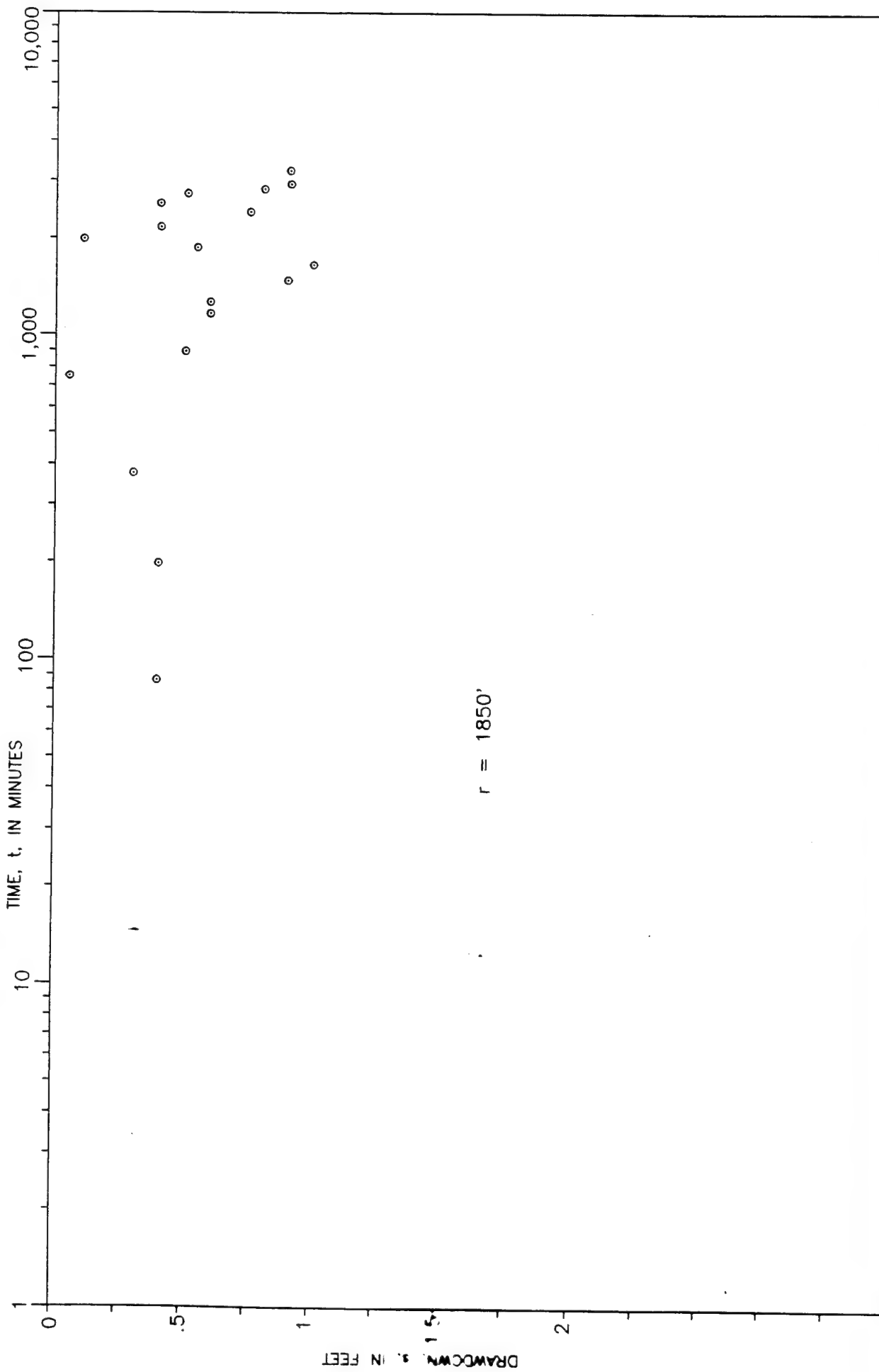
Figure

2-16



Metcalfe & Eddy





LEXINGTON BLUEGRASS ARMY DEPOT

# DRAWDOWN VS. TIME IN WELL MW40

LEXINGTON, KENTUCKY

Project Number

012308-0006

File Name

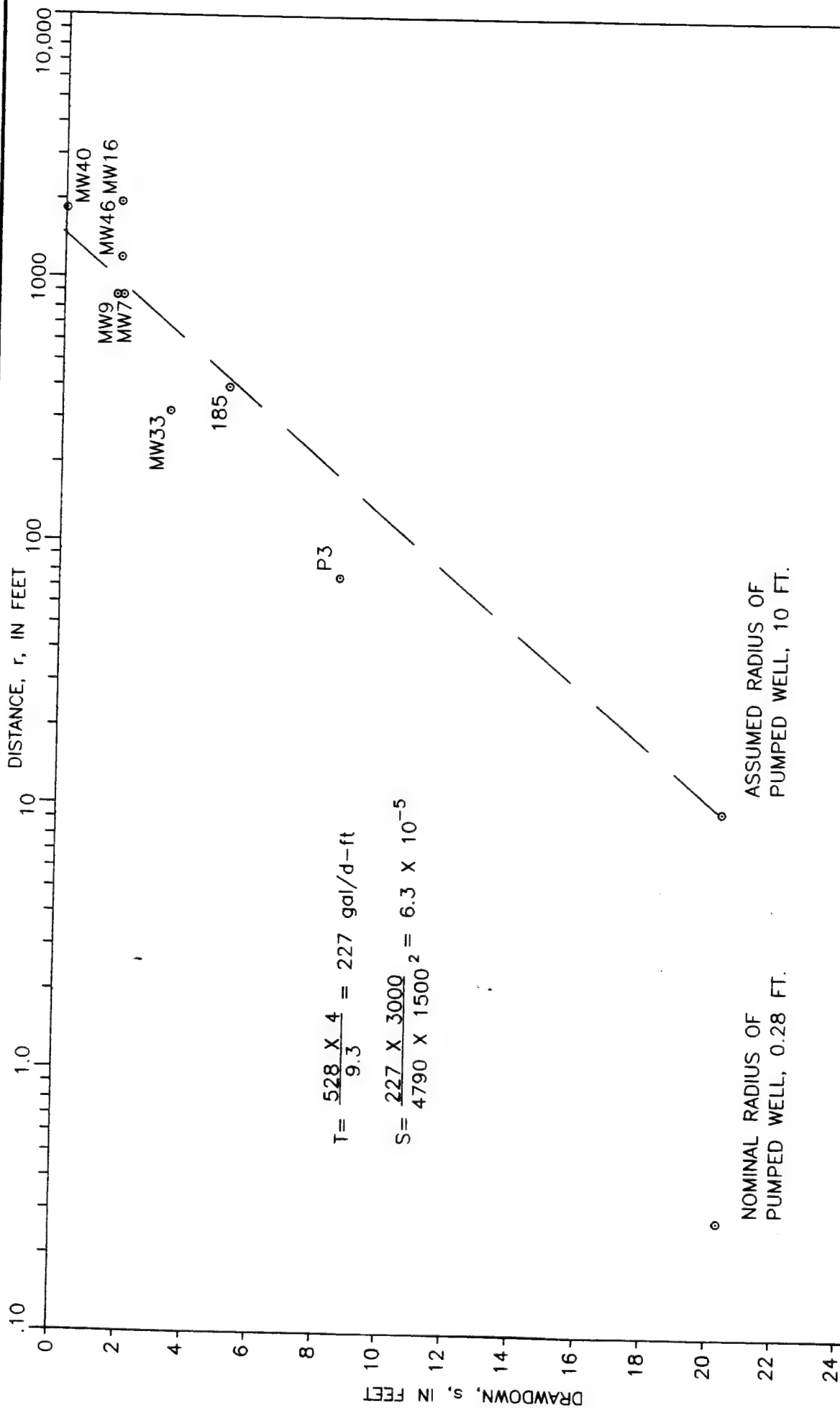
TIME-1

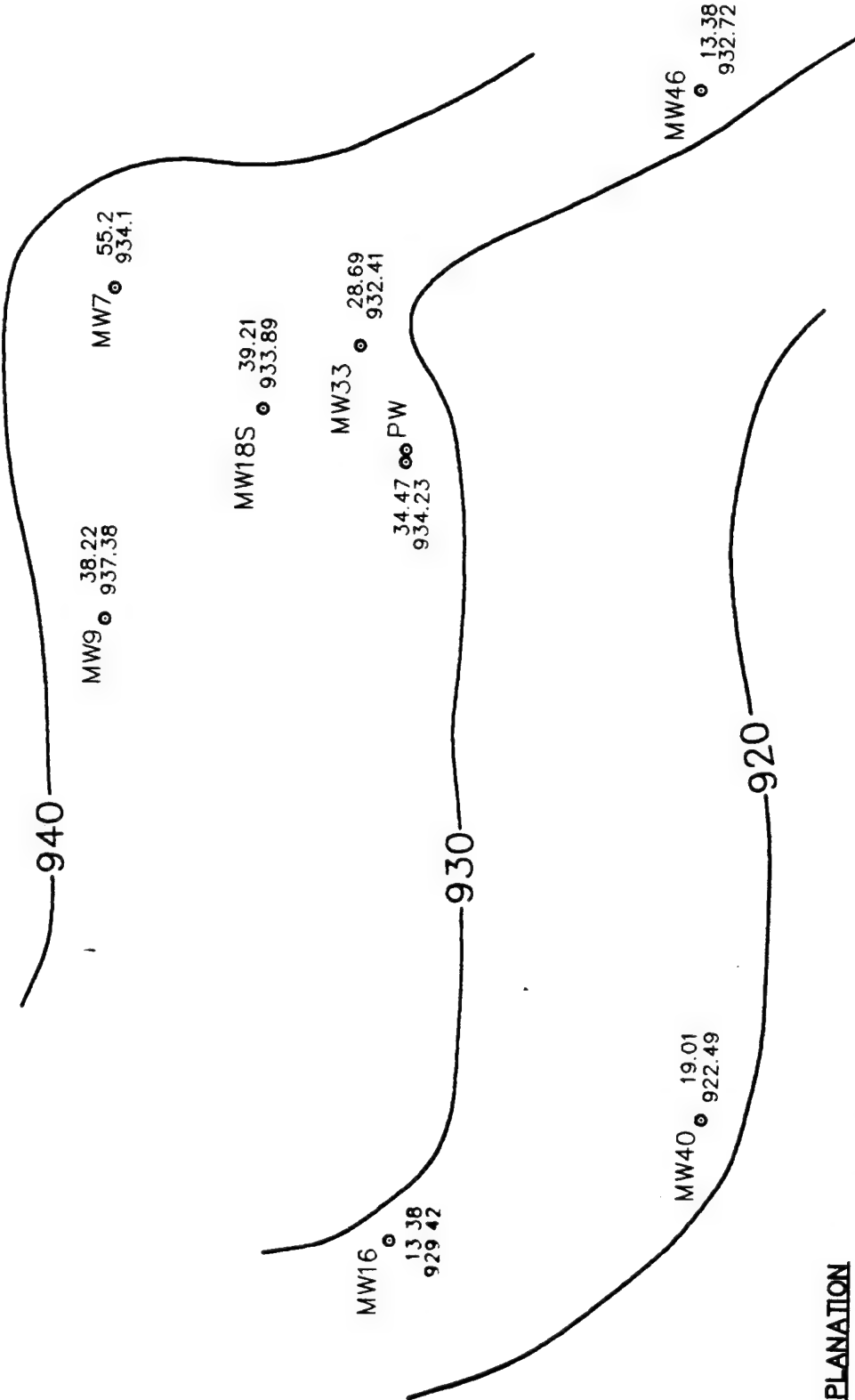
Figure

2-17



Metcalfe & Eddy





SCALE IN FEET  
0 437.44

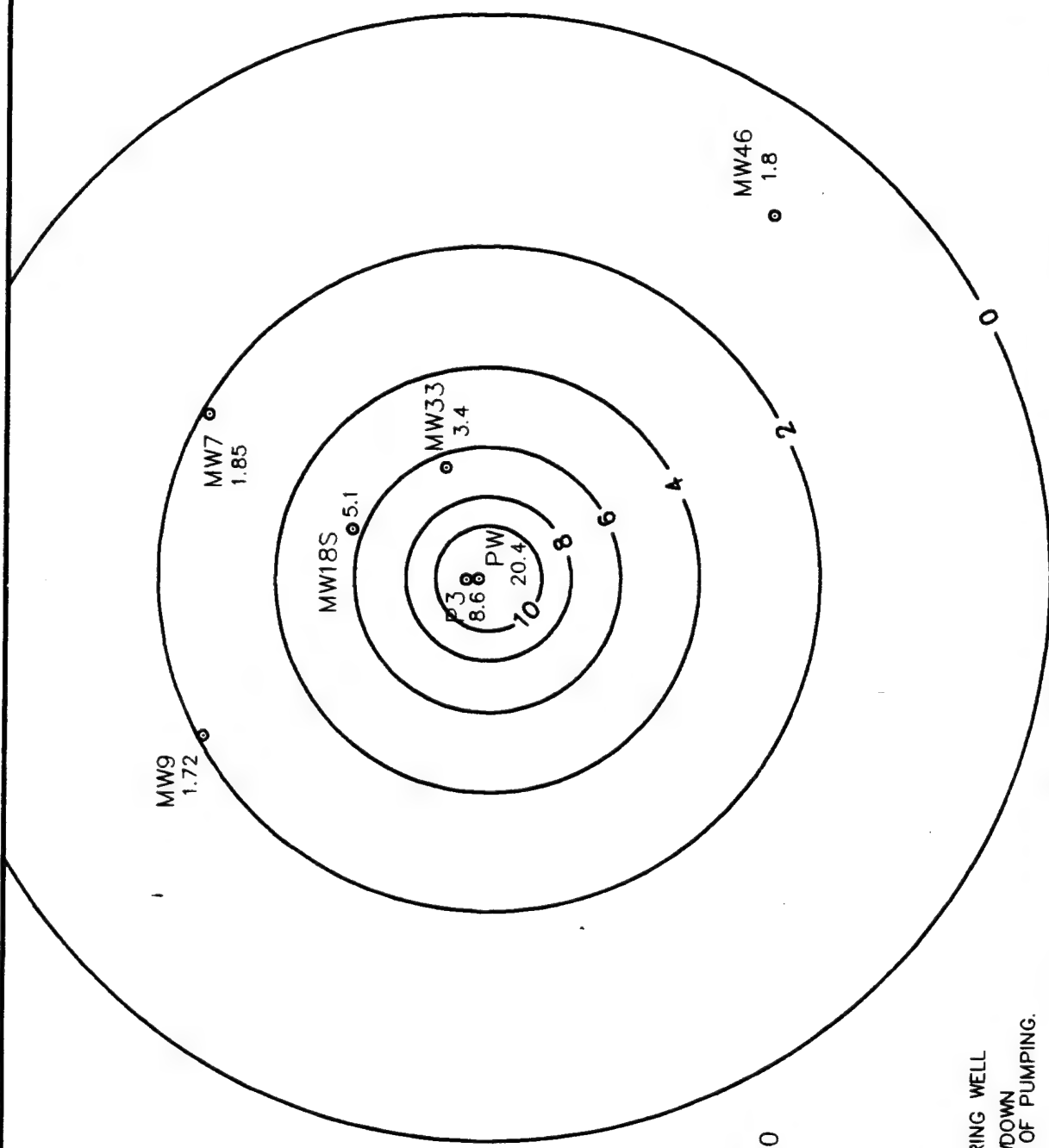
Project Number		012308-0006
File Name	Figure	12308-1 2-19

**EXPLANATION**

- LOCATION OF MONITORING WELL
- TOP NUMBER IF DEPTH TO WATER BELOW MP.
- BOTTOM NUMBER IS ELEVATION OF THE WATER TABLE (MSL)

**M&E**  
Metcalf & Eddy

LEXINGTON BLUEGRASS ARMY DEPOT  
**CONTOUR MAP OF THE WATER TABLE JUST PRIOR  
TO THE PUMPING TEST ON AUG. 28, 1993**  
LEXINGTON, KENTUCKY



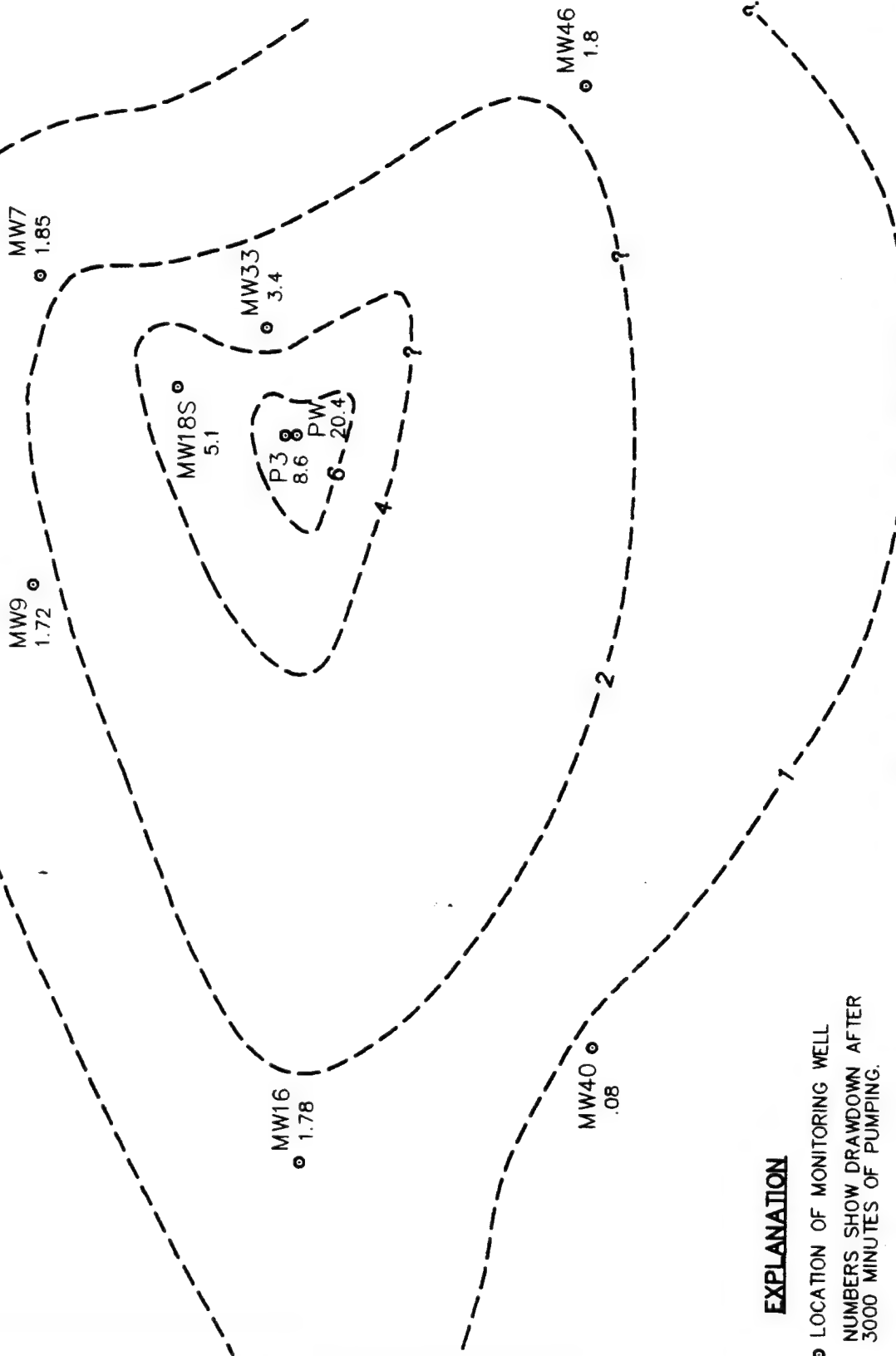
**EXPLANATION**

- LOCATION OF MONITORING WELL
- NUMBERS SHOW DRAWDOWN AFTER 3000 MINUTES OF PUMPING.



LEXINGTON BLUEGRASS ARMY DEPOT  
HYPOTHETICAL CONTOURS OF DRAWDOWN AFTER 3000 MIN. OF  
PUMPING, BASED ON THE "AVERAGE" STRAIGHT-LINE PLOT IN FIG. 11  
LEXINGTON, KENTUCKY

Project Number	012308-0006
File Name	12308-1
Figure	2-20



### EXPLANATION

- LOCATION OF MONITORING WELL
- NUMBERS SHOW DRAWDOWN AFTER 3000 MINUTES OF PUMPING.



## LEXINGTON BLUEGRASS ARMY DEPOT CONTOUR MAP OF DRAWDOWN AFTER 3000 MINUTES OF PUMPING BASED ON FIELD MEASUREMENTS. LEXINGTON, KENTUCKY

Project Number 012308-0006	
File Name 12308-1	Figure 2-21

### **3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA**

#### **3.1 REGIONAL GEOLOGY**

The Lexington area is near the crest of the Cincinnati Arch, a broad, low structural feature whose long axis extends generally northward from Tennessee through central Kentucky and western Ohio into southern Michigan. The area is underlain by essentially flat-lying rocks of Ordovician age, consisting chiefly of alternating beds of limestone and shale belonging to the Lexington Limestone. These rocks are capped on the higher hills by remnants of the lithologically similar Clays Ferry Formation (see stratigraphic column, Figure 3.1).

LBAD is in the east central part of a 5,600 square mile area, centered near the City of Lexington, termed the Inner Bluegrass Karst Region. Karst is defined as a type of topography formed on limestone and other rocks of dissolution and is characterized by sinkholes and underground drainage (Bates and Jackson, 1980).

Several investigations have been made in portions of the Inner Bluegrass Karst Region that have aided in the interpretation of the ground-water flow system at LBAD. Hamilton, in two reports (1948, 1950), presented evidence to show that dissolution, and well yield, are greatest beneath topographically low areas. In his study area south of Lexington, the depths of solutional openings, and productive wells, is limited to about 80 feet (Hamilton 1948, page 45). Hamilton states that poorly soluble units such as argillaceous limestone and shale, inhibit the development of solutional openings in rocks that underlie them.

Hendrickson and Krieger (1964), reporting on the geochemistry of natural waters in the Blue Grass Region, state that wells drilled along surface streams are the best producers, which supports Hamilton's findings, and that ground-water movement is controlled chiefly by topography.

Mull (1968), in an investigation covering parts of Fayette and Scott Counties, reported that the direction of ground-water flow was controlled by the topography and also the dip of the rocks. The area studied by Mull was on the western flank of the Cincinnati Arch where the dip is much greater than it is at LBAD, which is near the crest of the arch where the rocks are nearly flat-lying.

A report by Faust (1977) presents a potentiometric map of a six county area in the Inner Blue Grass Region which conforms generally to the topography, and further supports the work of the previously cited investigators with respect to the occurrence and movement of ground water. Faust also shows that well yield is related both to topography and stratigraphy, as first demonstrated by Hamilton.

A more recent report, by Thrailkill and others (1982), gives results of an investigation of ground-water flow based on dye tracing techniques. The authors introduced dye into sinkholes and identified the spring, or springs, at which the water emerged. Ground-water basins were delineated by encompassing areas "believed to be underlain by an integrated conduit system" (page 56). They point out that the total catchment area of the spring is usually much larger, since it includes areas of shallow subsurface or surface flow outside the basin boundaries.

Thrailkill and others (*ibid*) identified about 50 ground-water basins with areas up to 5.8 square miles. They state (page ii) that, within the basins, ground-water flow occurs within a dendritic conduit system, reaching depths as great as 100 feet. In interbasin areas, by contrast, ground-water flow is restricted to depths of about 15 feet. Also, within ground-water basins some conduits have breached poorly-permeable beds and water may descend almost vertically to deeper conduits.

The authors measured the discharge from 30 springs in their study areas, associated with specific ground-water basins. They report that median discharge averaged about 0.118 mgal/day per square mile. This is equivalent to 2.48 inches of rainfall per year, about 5.5 percent of the average annual precipitation for the region of approximately 45 inches.

The area studied by Thrailkill and others did not include LBAD. The closest basin in their study was one of about 3.5 square miles where water discharging from the Grier Limestone Member emerges at Russell Cave Spring, about five miles southwest of the Facility. The authors state that an argillaceous unit at the base of the overlying Tanglewood Member has probably been penetrated. The authors also state that the Russell Cave Spring ground-water basin bears little relationship to the surface drainage.

Areas favorable to the techniques of investigation used by Thrailkill and others were selected because they contained both sinkholes and springs. As neither feature is characteristic of LBAD, it is impossible to directly apply their methodology and interpretation to this site. Evidence shows that the ground-water flow system at LBAD is more like that described by Hamilton (1948, 1950) in that there are no large conduits and the water table, though semi-perched in places, generally replicates the surface-water

drainage. Ground water discharges locally into streams and there appears to be little or no interbasin movement of water.

### **3.2 SITE GEOLOGY**

As stated previously, LBAD is located within the Inner Bluegrass Karst Region and is underlain by the Lexington Limestone (see Figure 3-2).

Locally, the Lexington Limestone includes four members. From top down, they are: The Upper Tongue of the Tanglewood Limestone, the Millersburg Limestone, the Tanglewood Member, and the Grier Limestone Member. All members except the Grier Limestone are exposed at the surface on LBAD property. The top of the Grier Limestone was reached by relatively deep monitor wells drilled during this investigation at depths ranging from 50 to about 100 feet. The four water-supply wells formerly used at the Facility bottomed in the Grier Limestone at depths ranging from 141 to 151 feet.

The highest stratigraphic units at the Facility, The Clays Ferry Formation and the Upper Tongue of the Tanglewood Limestone, are represented by erosional remnants confined to the higher hills in the northern part of the property. The Clays Ferry Formation occurs as small patches on the hill tops above elevation 1020 feet, and the Upper Tongue of the Tanglewood occurs between elevations 1,005 and 1,020 feet. The Clays Ferry Formation is shaley in composition and of low permeability. The Upper Tongue of the Tanglewood, so called because of its lithologic similarity to the Tanglewood Member, contains less shale and is more permeable than the Clays Ferry. However, because of their limited areal extent, both of these units are considered unimportant with respect to ground water at the Facility.

The rocks underlying most of the Facility property are part of the Millersburg Limestone which occurs approximately between elevations 945 and 1,005 feet.

The Millersburg Member is divided into four units which differ slightly in lithology. All units are approximately 50 percent limestone interbedded with 50 percent shale (MacQuown, 1968). According to Cressman (1973), the Millersburg Member is 35 percent insoluble. Rock core COR-1, drilled by Metcalf & Eddy at the New Landfill, started at elevation 1,007.4 feet, and the full thickness of the Millersburg Member was cored. (See Appendix B for core logs and photos and Figure 3-3 for Core cross sections.) The Geologic Map of the Clintonville Quadrangle, Central Kentucky (MacQuown, 1968) shows a locally mapped tongue of the Tanglewood Member at approximately 970 feet and an argillaceous



zone at approximately 960 feet. Neither of these units could be identified during coring. Neither could they be identified when the Millersburg Member was cored by Stokley-Cheeks and Assoc., Inc. (Stokley-Cheeks, 1980) when siting the Fayette County Landfill.

Beneath the Millersburg Limestone, and exposed by erosion in a quarter-mile wide band on both sides of the stream and its tributaries that border LBAD to the south and west, is the Tanglewood Limestone Member. The Tanglewood Member, like the Millersburg Limestone, consists of alternating beds of limestone and shale, but it contains relatively more limestone beds (80 percent versus 50 percent for the Millersburg), and is more permeable than the Millersburg because of greater dissolution. Cressman (1973) reports only 5 percent insoluble material in the Tanglewood.

The Tanglewood Member is 30 to 35 feet thick at the Facility where fully present, that is, where it has been protected from erosion by the overlying Millersburg Limestone. The Tanglewood Member occurs at elevations below about 945 feet. The upper 10 to 12 feet is transitional with the overlying Millersburg Limestone. The Millersburg/Tanglewood contact was cored (COR-1, COR-2, COR-4) but no distinct contact could be determined.

The Grier Limestone Member, which underlies the Tanglewood Member, is 135 feet thick and is composed of 80 percent limestone and 20 percent shale (MacQuown, 1968). In places, shale occurs as thin irregular laminae separating nodules of limestone. Cressman (1973) calculated the insoluble content of the Grier Member as only 8 percent. Mull (Mull, 1968) states that the Grier Limestone Member contains beds of shale in the middle and a thin bed of argillaceous limestone at the top. At the Facility, the elevation of the shale beds would be approximately 840 feet elevation and the argillaceous limestone bed would be at approximately 900 feet. Four cores were drilled by Metcalf & Eddy through these contacts. Although limestone/shale interbedding was encountered, no distinct shale beds or argillaceous unit was discernable.

### **3.2.1 Groundwater Occurrence On-site**

Interpretation of site hydrogeology is based on information from the installation of 27 shallow monitoring wells, 12 deep monitoring wells, two soil/rock interface wells, four piezometers and 20 dry holes. The investigation included water-level measurements and sampling of the newly installed wells, and of pre-existing monitor wells at the Facility, as well as slug testing of 10 shallow monitoring wells, a pumping test, and a dye trace test. Additional data were obtained from the examination and analysis of well logs

from previously installed wells, and the study and interpretation of topographic and geologic maps and aerial photographs of the site.

Site topographic maps and aerial photographs were examined for fracture traces, sink holes, surface depressions, or vegetation trends to possibly identify differential subsurface flow patterns. No such trends could be identified; however, wells were placed whenever possible within topographic lows and surface water drainage channels.

In 1981, 13 monitoring wells were installed at the Facility as part of an environmental survey conducted for USAEC by a contractor (USATHAMA, 1983). Well locations are shown in Figure 2.4. The wells were screened either at the bedrock/soil interface or in the fractured section just below this interface. Environmental Science and Engineering, Inc. (USATHAMA, 1983) stated that, based on water level data and recovery rates, the wells appear to be open in more than one hydrologic zone. An upper bedrock zone was identified above approximately 990 feet elevation which was described as the "relatively transmissive, unconsolidated top-of-rock zone". A second zone, called the middle bedrock zone, was between 990 feet and 940 feet. This zone was described as "less transmissive and relatively tight". A third or lower bedrock zone was reported as very transmissive, and that wells installed in this zone were capable of yields of several hundred gallons per minute. It should be noted that the zone identified as the upper transmissive zone is the fractured zone at the bedrock/soil interface noted by Hamilton and others. The middle, less transmissive zone coincides approximately with the lower limits of the fracture system in topographically high areas. The lower transmissive zone was identified only in areas of topographic lows. The contact between the lower transmissive zone and the middle transmissive zone roughly coincides with the contact between the shaley, Millersburg Limestone, and the more soluble Tanglewood Limestone Member. However, the data collected and the three-zone interpretation can be better explained by the interpretations proposed by Hamilton.

During November, 1991; May, July, and August, 1992; and September, 1993, Metcalf & Eddy installed 39 monitoring wells at LBAD. Twenty five monitoring wells were installed as shallow wells, two as interface wells, and 12 as deep wells. In addition, 20 borings were drilled but not completed as wells because water was not encountered. All wells were installed according to the procedures described in Section 2.4.2. The locations of all shallow, interface, and deep wells installed by Metcalf & Eddy, as well as previously installed wells, are shown in Figure 2.4. Well numbers, elevations, depths to rock, elevations of first water, and total depths are given in Table 2.1. Well-construction diagrams are in Appendix D. Drilling logs are in Appendices E and F.

The shallow wells on-site were all screened at first water, and were all good producers. These wells were developed and purged using a 2-inch Grundfos® purge pump according to the procedures outlined in Section 2.4.3. The required volumes needed for development were easily pumped. See Table 2-3 for well numbers, dates installed, required purge volumes, and actual purged amounts. Slug tests were performed on ten of these shallow wells. See Section 2.5.1 for a discussion of slug test results. See Appendix G for Slug test data. The mean hydraulic conductivity values resulting from the slug tests were  $3.5 \times 10^{-3}$  cm/sec. A pumping test was also performed at LBAD on this first water zone. See section 2.5.2 for pump test results. The average transmissivity derived from the pumping test was 416 gal/day/ft. In addition to the slug tests and the pumping test, a dye trace test was conducted at this first water zone. Results of the dye trace can be found in Section 2.5.3. All shallow wells installed by Metcalf & Eddy are screened in a high production zone of the Tanglewood Limestone.

Owing to the lack of productive monitoring wells in the northeast quadrant, and the location there of the New Landfill, two interface wells were installed within major swales draining from the New Landfill. Conventional monitoring wells had been attempted (MW-24, MW-26) in both of these swales, but the attempts were unsuccessful. See Figure 2.4 for the locations of interface wells MW-43I and MW-44I. These wells were installed using a 10-foot screen and were constructed such that the soil/rock interface was straddled. This allowed monitoring of any "top-of-rock" flow from the New Landfill in conjunction with previously installed, similarly constructed wells.

Twelve deep wells were installed by Metcalf & Eddy during July and August 1992, and September 1993, the locations of which are shown in Figure 2.4. The well logs are given in Appendix E. The deep wells were paired with shallow wells at the same location. Each deep well was installed using a 20-foot long screen positioned so that the top of the screen was 20 feet below the bottom of the corresponding shallow well screen. The well was constructed with 5 feet of sand pack above the top of the screen so that 15 feet of unscreened interval exists between the bottom of the shallow well and the top of the deep well. Each deep well was developed according to procedures outlined in Section 2.4.3. Table 2.3 contains the well numbers, dates installed, required purge volume, and actual volumes purged. All deep wells, with the exception of MW-08D and MW-40D, MW-47D, and MW-48D, were very slow to recover. These four wells were the only wells which recovered quickly enough to allow the proper volume of water to be purged for development within the allotted time. This lends credence to the reports by previous investigators that conduit development decreases with depth and the water-bearing zone is relatively shallow in interstream areas.

Twenty borings were drilled but not completed as wells. The locations of these "dry holes" are shown on Figure 2.4. The depth of each boring is given in Table 2.2. It should be noted that the deepest boring drilled which did not encounter water was boring MW-11 which was drilled to a depth of 125 feet. The lowest elevation reached was well MW-17, completed to an elevation of 887.1 feet. The majority of the "dry holes" were in the northern and topographically highest part of the Facility. In general, the chances of wells encountering water coincide with interpretations made by Hamilton. Wells located within topographic depressions and at lower elevations were more productive than wells at higher elevations not located in swales or topographic depressions. For instance, only one well, MW-23, was productive out of 10 drilling attempts within the northeast upland area of the facility. This is the highest quadrant of the Facility, topographically. The dearth of productive sites within this quadrant is consistent with the findings by Thrailkill (1982), that conduit development beneath more than 30 feet of the Clays Ferry Formation or the Millersburg Member would be minimal. This area of the Facility contains the greatest thicknesses of both Members.

Four rounds of water-level measurements were made in the monitor wells. The measurements were made according to the procedures outlined in Section 2.4.5, on January 10, 1991; March 16, and September 21, 1992; and December 9, 1993. Table 2.1 shows water levels for all four sets of measurements. Figure 3.4 is a potentiometric map based on the September 21, 1992 water levels of the existing and shallow wells. Although the potentiometric surface fluctuates between different rounds of water level measurements, the geometry of the potentiometric surface remains the same.

As shown by the potentiometric map a ground-water divide exists in the area of the New Landfill. Ground water as well as surface water on the north side of the divide flows north to Hutchinson Creek. Water on the south side of the divide flows south to a tributary of Elkhorn Creek. The potentiometric surface conforms to the topography, with steeper gradients near the divide and lower gradients near the streams. As evident from the rock cores (Appendix B), many shallow partings and beddings occur within the screened zones of the monitor wells. Because of the limited number of deep wells installed at LBAD, it was not possible to construct a site-wide, deep-well potentiometric surface map. However, when water levels in the deep wells are plotted with the water levels in the corresponding shallow wells, it is evident that a downward gradient exists generally between the deep wells and the shallow wells, the difference being as much as 56 feet. This difference in water levels appears to exist throughout the site with the exception of the low area near the southern boundary (see Figure 3-5).

Where water-level data are limited, the potentiometric contours are drawn to conform fairly closely to the surface contours, but at a somewhat lower level; the relationship is extrapolated from conditions observed where water-level data are relatively abundant.

In the shallow wells installed during this investigation, the water level rose above the level at which "first water" was reported by the driller. Immediately after encountering first water, generally between depths of 10 to 50 feet, drilling was stopped and the water level allowed to rise until it had essentially "leveled off", after which drilling was resumed and the hole deepened sufficiently for a 10-foot-long screen to be installed. The screened zone straddles the depth interval in which the first water was reported.

As a general rule, if water was not encountered above a depth of approximately 100 feet at a given site the boring was terminated. However, the deepest boring in which water was not encountered was at site MW-11, near the New Landfill, which was drilled to the depth of 125 feet, well below the elevation where water was encountered at lower elevations.

The deepest depth at which first water was encountered was 69 feet in MW-7, about 1,000 feet north of the main buildings at the northeast corner of the Industrial and Sanitary Waste Landfill. The elevation of MW-7, 989 feet, is relatively high compared with nearby wells. However, the potentiometric level in MW-7 is generally accordant with that of the other wells.

The shallowest depth at which first water was encountered was 12 feet below grade in MW-3 and MW-16, both in relatively low areas in the southwestern part of LBAD near the Old Landfill.

As reported by the driller and observed by the field geologist, the strata were essentially "dry" above the first water zone. Also, as previously stated, when water was encountered, it invariably rose above the depth at which it was reported. At first, this would lead one to believe that this was a confined aquifer system; however, as discussed in Section 2.5.2, water occurs in joints and openings in the rocks at various depths, but seeks a common level that is the water table. The chances of intersecting a water filled opening precisely at the water table would be rare. Therefore, when water is encountered, it is typically intercepted below the water table, and rises within the well.

As ground water moves from higher to lower potentiometric levels in the main aquifer, it also moves downward through the less soluble beds of the Millersburg Limestone into the underlying and more soluble Tanglewood Member. This movement results in the progressive enlargement, downgradient, of

solution channels and conduits through which the water moves. There is little circulation and downward movement at higher elevations where the Millersburg Limestone is thickest. There is enhanced circulation and greater dissolution at lower elevations in the Tanglewood Member, where the Millersburg Limestone is relatively thin. This is especially true where the Tanglewood Member is exposed at the surface.

In the resulting flow system, defined by water levels in the monitor wells, ground water occurs in a network of generally interconnected conduits that may be isolated locally from each other, but which become more numerous and better integrated downgradient, especially near discharge points such as the principal stream that flanks the main buildings at the southern edge of the property. This effect is shown by the flattening of the potentiometric contours in the southern part of the property and can be seen in Figure 3-4 and 3-5. The potentiometric surface is relatively flat in the low area because flow pathways are more numerous and better connected and aquifer transmissivity is higher than in upland areas.

In conclusion, the flow system at the Lexington Facility can best be described as one aquifer occurring at three varying degrees of development across the site. See cross sections in Figure 3-2. These degrees of development consist of first: top of rock flow, second: a highly transmissive zone within the Tanglewood formation, and third: a more highly developed transmissive zone within both the Tanglewood Formation and the Grier Formation in the low areas.

Within the higher elevations of the northeast portion of the study area, only top of rock flow exists. This is evident by the many unsuccessful wells drilled within this area, and the necessity to install bedrock/soil interface wells. The fracture development within this zone appears to be shallow, and contains groundwater flow only during storm events. It should be noted that due to the lack of groundwater within this section of the facility, the risk assessment will deal with this area separately from the remainder of the Base.

As groundwater moves down topographic gradient, as well as horizontally and vertically within the stratigraphic column, the relatively insoluble Millersburg Formation is breached. This then allows for increased dissolution to occur within a relatively thin zone of the Tanglewood Limestone. This highly transmissive zone was intercepted by the previously described shallow wells. The high degree of fracture/solution integration is evident from both the slug tests and the pumping test performed on this section of the aquifer as well as the existence of a noted flattening of the potentiometric surface. The aquifer thickness is less than 25 feet and may be less than 10 feet. This is evident by the potentiometric

surface within the deep wells, compared to the potentiometric surface within the shallow wells. See cross section Figure 3-5. The deep wells are constructed such that only 15 feet of unscreened zone exists between the top of the deep well and the bottom of the corresponding shallow well. Even given this lack of separation, the deep wells consistently have a lower potentiometric surface. The degree of separation appears to depend solely on the degree of fracture integration with depth in the vicinity of the well. Therefore, fracture density drops considerably within only 15 feet of depth. This pattern is consistent until you continue down gradient closer to the discharge area where, as can be seen from the cross section, the two potentiometric surfaces merge along the unnamed tributary of Elkhorn Creek at the southern boundary of the facility.

This third area of fracture/solution development is characterized by a high degree of fracture/solution integration both horizontally and vertically. This is evident by the high productivity of both the shallow and the deep wells as well as the merging of the two previously mentioned potentiometric surfaces. The area borders the unnamed tributary of Elkhorn Creek and acts as a local surface water and groundwater discharge point. This highly transmissive zone has developed due to the total erosion of the Millersburg Limestone, as well as the exposure and thinning of the Tanglewood Formation. Within this area, the aquifer appears to be at least 25 feet thick, as evident by the lack of separation between the potentiometric surfaces in the shallow and deep wells, and probably extends well into the Grier Formation.

In short, the aquifer at LBAD can be described as an immature Karst Aquifer with water occurring in a network of generally interconnected fractures and minor solution openings that may be isolated locally from each other. The fractures and solution openings become more numerous and better integrated downgradient and within more soluble formations, but generally decrease with depth.

### **3.2.2 Groundwater Flow Direction and Hydraulic Gradient**

The potentiometric surface and thus the groundwater flow direction generally replicates the surface topography (see Figure 3-4). A groundwater divide exists in the northeastern section of the base in the vicinity of the New Landfill. Ground water, as well as surface water on the north side of the divide, flows north to Hutchinson Creek, while water on the south side flows to a tributary of Elkhorn Creek. As water flows south off the topographic high, it moves either downgradient to the southeast, the northwest, or due south. If the water flows southeast, it will discharge into the tributary of Elkhorn Creek. If it flows northwest, it will discharge into the drainage area on the western boundary of the Base and eventually discharge into the unnamed tributary of Elkhorn Creek. If it flows due south, it will



discharge directly into this unnamed tributary. Therefore, all surface water or ground water, within the Facility, with the exception of the small amount which flows north to Hutchinson Creek, eventually discharges to the south to the unnamed tributary of Elkhorn Creek.

As with the surface topographic gradient, the hydraulic gradient steepens as water moves off the high areas of the base toward the drainage area at the western base boundary. For instance, the gradient between well MW-1123 and MW-35 is 0.06 with a 42.4 foot drop over only 656.2 feet of run. As previously discussed, the hydraulic gradient flattens as water moves to the discharge area at the southern section of the base. For instance, the gradient between well MW-07 and MW-40 is as low as 0.004 with only 10.1 feet of drop over a 2,624.6 foot run. As one can see from the potentiometric surface map, the hydraulic gradient varies considerably throughout the site, but it steepens moving off the topographic highs and then flattens toward the discharge area to the south.

### **3.2.3 Aquifer Characteristics**

As stated in Section 3.2.1, the aquifer at LBAD can best be described as an immature karst aquifer occurring at three varying degrees of development across the site. The first degree of aquifer development is primarily located in the northern section of the facility within the Millersburg Limestone. This section of the aquifer consists of top of rock flow only. The top of rock aquifer zone, based on boring logs and well data, is a thin, highly transmissive zone which is saturated only during storm events. The fracture depth, and thus the aquifer thickness is probably less than 15 feet below the soil/bedrock interface.

The second degree of aquifer development occurs further down gradient, within the more soluble Tanglewood Limestone. This portion of the aquifer is screened by the shallow wells installed by M&E. It consists of a highly transmissive zone occurring generally within 50 feet of the land surface. As evident by the differences in the potentiometric surfaces of the deep versus shallow wells, the aquifer is, at most, 25 feet thick. This section of the aquifer is very transmissive. Slug tests performed on 10 wells within this section of the aquifer yielded hydraulic conductivity values ranging from  $2.3 \times 10^{-4}$  to  $9.4 \times 10^{-1}$  cm/sec. The mean hydraulic conductivity for all 18 slug tests was  $3.5 \times 10^{-3}$  cm/sec. A pumping test was also performed on this zone of the aquifer in the vicinity of well MW-32. Transmissivity values derived from the pumping test ranged from 129 to 744 gallons per day per foot (gal/d/ft) with the average transmissivity of 416 gal/d/ft. If the large values are omitted, all of which are relatively far from the pumping well, a more realistic average is 227 gal/d/ft.



The third, and most highly developed section of the aquifer is located along the southern edge of the property adjacent to the unnamed tributary of Elkhorn Creek. Within this section of the aquifer, fracture density and depth increases considerably. The transmissivity is at least as high as the values previously stated, as evident by well recovery during development, as well as historically reported pumping rates of onsite production wells which were screened within this section of the aquifer. The degree of fracturing and solution within the aquifer thickness also increases dramatically. This is evident by the convergence of the potentiometric surfaces within the deep and shallow monitoring wells.

### 3.2.4 Groundwater Velocity

The aquifer at LBAD is an immature karst aquifer which is characterized by a network of generally interconnected fractures and minor solution openings. Although this is an immature karst aquifer, flow characteristics can be approximated using Darcy's Law. According to Thrailkill (Thrailkill, 1982), "Subsurface flow in an area underlain by granular material is largely through pores of such small diameter that flow velocity is linearly related to the potential gradient by the hydraulic conductivity, a relationship described by Darcy's Law. In addition, flow in small planar fractures (e.g., joints and bedding surfaces) will obey this relationship if the width of the fractures is sufficiently small." Thrailkill goes on to say that "because the Lexington Limestone is thin-bedded and the individual beds are jointed, pre-conduit flow along bedding and joint surfaces, which will collectively be called fractures, would seem likely. Such flow in a system of narrow fractures (assuming certain conditions of their interconnection and spacing are met) will obey Darcy's Law and is here considered saturated intergranular flow, even though the flow paths are not between grains."

Given this premise, velocity can be defined by the following equation derived from Darcy's Law.

$$V = \frac{K \frac{dh}{dl}}{N_e}$$

where:

V	=	mean groundwater particle velocity in length per time
K	=	hydraulic conductivity in length per time
dh/dl	=	hydraulic gradient in length per time
N <sub>e</sub>	=	effective porosity, unitless decimal

Aquifer hydraulic conductivity was derived from slug tests performed on 10 of the shallow wells installed by M&E. Aquifer transmissivity was derived from a pumping test performed at well MW-32. It is generally accepted that a more realistic representation of aquifer properties can be derived from a pumping test versus a slug test. Therefore, for this discussion, pumping test data will be used.

Transmissivity values derived from the onsite pumping test ranged from 129 to 744 gal/d/ft and averaged 416 gal/d/ft. If the larger values are omitted, all from wells relatively far from the pumping well, the average is 227 gal/d/ft, which is considered more representative of the aquifer.

Aquifer thickness within the main portion of the study area is believed to be between 10 and 25 feet thick.

The hydraulic conductivity can be defined as:

$$K = \frac{T}{b}$$

where:

K	=	Hydraulic Conductivity
T	=	Transmissivity
b	=	Aquifer Thickness

Therefore:

$$K = \frac{227 \text{ gal/d/ft}}{10 \text{ ft}} = 22.7 \text{ gal/d/ft}^2$$

or if the greater thickness of the aquifer is used (25 feet), then:

$$K = \frac{227 \text{ gal/d/ft}}{25 \text{ ft}} = 9.1 \text{ gal/day/ft}^2$$

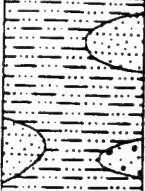
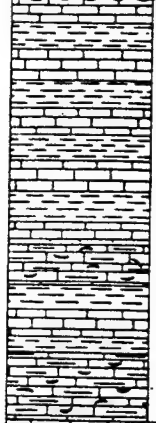
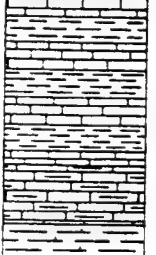
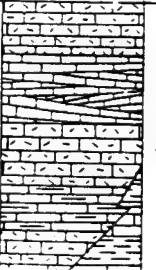
Therefore, the hydraulic conductivity values believed to be representative of the aquifer at LBAD range from 22.7 gal/day/ft<sup>2</sup> to 9.1 gal/day/ft<sup>2</sup>, depending on the assumed thickness of the aquifer.

As discussed in Section 3.2.2, the hydraulic gradient varies considerably throughout the site. Gradients range from 10.1 ft per 2624.6 ft to 42.4 ft per 656.2 feet.

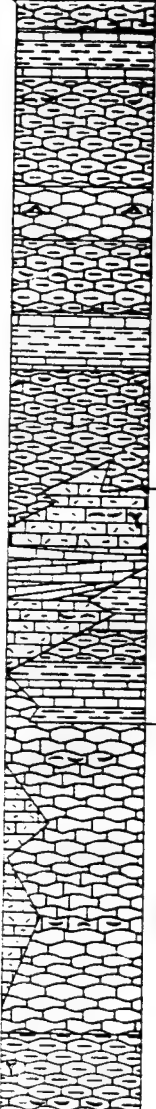
No specific tests of porosity were conducted at LBAD during the groundwater study, but Freeze and Cherry (1974) states that the porosity of a Karst Limestone aquifer ranges from 0.05 to 0.50. This same range is also cited by Sevee (1991). As stated previously, the aquifer at LBAD is an immature karst aquifer; therefore, the lower to mid range of values would be expected to be more realistic. Values of 5 to 25 will be used for calculation purposes.

In summary, the hydraulic conductivity for the LBAD aquifer is expected to be between 22.7 gal/day/ft<sup>2</sup> and 9.1 gal/day/ft<sup>2</sup>, the hydraulic gradient is between 0.06 and 0.004, and the porosity is expected to be between 0.05 and 0.50. Therefore, if we convert the conductivity from gal/day/ft<sup>2</sup> to feet/day, we get 3.0 feet/day and 1.2 feet per day for conductivity values. Using these previously stated ranges, groundwater velocities would range between 1314 feet per year and 7 feet per year.

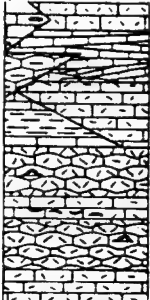
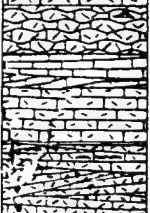
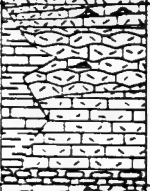
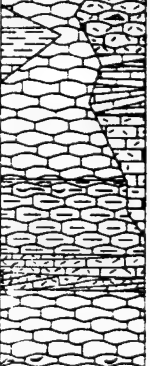
If the area around MW-32, where the most reliable data was collected, is considered specifically, the lower velocity is expected to be more representative due to the low hydraulic gradient.

SYSTEM	SERIES	FORMATION, MEMBER, AND BED	LITHOLOGY	THICKNESS, IN FEET	DESCRIPTION
QUATERNARY		Alluvium		0-10?	Clay, silt, sand, and gravel; generally less than 10 feet thick.
		Clays Ferry Formation		30+	Shale, limestone, and siltstone, interbedded. Shale (50 percent), dark-greenish-gray, limy in part; contains thin siltstone and silty shale laminae; fissile in part. Limestone (45 percent), olive-gray to medium-gray, shaly; some fine to coarse grained, poorly sorted; disseminated grains of silt and fossil fragments; lenticular beds in part; some dark-gray, micrograined tabular beds; beds generally less than 1/2 foot thick. Siltstone (5 percent), dark-greenish-gray, limy; weathered beds are buff to tan, porous in part, only slightly limy. Fossils, sparse to abundant in some layers, chiefly in limestone; some whole brachiopods, gastropods, and bryozoans, fragments of pelecypods and trilobites. Base of zone containing abundant small brachiopods commonly referred to as <i>Sowerbyella rugosa</i> occurs in lower 5 feet. Unit weathers readily to buff or tan soil; erosion develops steep slopes locally.
				10-15	Limestone (55 percent), shale (45 percent), siltstone (trace). Similar to overlying unit. Limestone up to 1 1/2 feet thick and more abundant in lower part, minor crossbedding; abundant fossil fragments with brachiopods and numerous crinoid columnals.
		Upper tongue of Tanglewood Limestone Member		10-18	Limestone and minor shale. Limestone, light-gray, medium- to coarse-grained; medium to thick tabular beds, cross-bedded in part; bioclastic; locally medium- to dark-gray thin shale beds, similar to those of underlying unit, inter-tongue with limestone beds near base of unit; fossils generally sparse, whole or fragmented; flat brachiopods in some beds; weathers to reddish-brown soil. Unit was called the Nicholas Limestone Member of the Lexington Limestone by Black and others (1965, p. 26-27), but further field work has indicated some doubt about its relation to the type Nicholas. Black and Cressman, oral communication, 1966). Because unit is lithologically similar to and continuous with the Tanglewood Limestone Member at its type locality, it is herein considered part of the Tanglewood Limestone Member.

RESOURCE: MacQuown, 1968.

SYSTEM	SERIES	FORMATION, MEMBER, AND BED	LITHOLOGY	THICKNESS, IN FEET	DESCRIPTION
ORDOVICIAN	Middle and Upper Ordovician	Lexington Limestone		25-30	Limestone and shale: Limestone (50 percent), gray, shaly, fine- to medium-grained, bioclastic; nodular and irregularly bedded; nodules occur in matrix of medium- to dark-gray shale; locally, thin shale and shaly limestone laminae around nodules of limestone. Minor interbedded tabular limestone and shale, greenish-gray claystone, and convolute limestone and shale "flow rolls." Fossils abundant; stromatoporoids occur in several zones in upper 15 to 20 feet; zones of abundant closely packed whole flat brachiopods. Fossils include <i>Rafinesquina winchesterensis</i> , <i>Cyclonema varicosum</i> , <i>Constellaria emaciata</i> (Foerste, 1914, p. 112). Weathers to thick yellowish clay soil with fossiliferous limestone rubble.
				10-14	Limestone, light-gray, medium- to coarse-grained; tabular bedded, crossbedded in part; bioclastic with abundant fossils locally including brachiopods and bryozoans; minor laminae of gray, fine-grained limestone and dark-gray shale; locally contains interbeds similar to overlying and underlying units; thins to the east to less than 5 feet. Top of this tongue of the Tanglewood Limestone Member is mapped locally where exposed.
				15-26	Limestone and shale, interbedded; Limestone (50 percent), medium- to dark-gray, argillaceous, micrograined, some coarse-grained; tabular, thin beds with flat bedding planes; some fossil fragments. Shale, medium- to dark-gray, limy, thin-bedded to laminated; few fossils. Weathers to yellowish clay soil. Unit interbedded in part with overlying beds; thickens to east. Base of unit mapped locally.
				140-150	Limestone (50 percent) and shale. Lithology and fauna similar to that found in upper half of Millersburg Member. Particularly fossiliferous near base. Abundant <i>Allomychia stanaganensis</i> Foerste in basal 5 feet (identified by John Pojeta, USGS fossil collections, nos. 5104-5105-CO). Weathers to buff or tan soil. Lower beds, transitional with and interbedded with underlying unit, contain thin discontinuous tongues and lenses similar to the unmapped Devils Hollow Member consisting of a light-gray, coarsely crystalline, conchoidal limestone bearing numerous brachiopods or gastropods, weathering to a conspicuous, porous, fossiliferous chert float.

RESOURCE: MacQuown, 1968.

SYSTEM	SERIES	FORMATION, MEMBER, AND BED	LITHOLOGY	THICKNESS, IN FEET	DESCRIPTION
		Tanglewood Limestone Member		10-12	Limestone, shale and shaly limestone: Limestone (80 percent), light-gray, medium- to coarse-grained; thin to thick bedded, tabular beds dominant, some irregular bedding, crossbedded in part; phosphatic; bioclastic. Very fossiliferous to sparingly fossiliferous; stromatoporoid zones, locally persistent, occur at several levels, the most prominent occurs 30 to 35 feet below top of unit; <i>Columnaria</i> , <i>Conatellaria</i> , and <i>Rhynchotrema</i> are among common fossil genera (McFarlan, 1943, p. 18). Weathers to reddish-brown soil. Shale and shaly limestone (20 percent); shale, limy, medium-gray, mostly interlaminated with fine-grained shaly limestone in thin beds within the thicker-bedded limestone. Upper 10 to 12 feet of unit is interbedded with and transitional to overlying unit; locally contains beds similar to the unmapped Devils Hollow Member described above.
		Brannon Member		20-30	
		Grier Limestone Member		0-10	Limestone and shale, interbedded: Limestone (50 percent), medium- to dark-gray, micrograined, some medium-grained, locally siliceous or cherty, tabular bedded; beds less than 1/2 foot thick; locally fossiliferous in part, with trilobite fragments and sponge remains characteristic. Shale, medium- to dark-gray, limy, thin-bedded; few fossils. Convolute "flow rolls" occur locally. Unit weathers to buff or tan soil. Absent in northern half of quadrangle except for local cherty zones in the Tanglewood Limestone Member. Partly interbedded and intertongued with adjacent units.
				25+	Limestone and shale: Limestone (80 percent), blue-gray in fresh outcrops to brownish-gray where weathered; mostly nodular to irregularly bedded, thin to medium bedded, slightly phosphatic, fossiliferous; some light-gray, medium- to coarse-grained, coquinoid, fossil fragment beds; some light gray, very fine grained, tabular bedded, thin bedded, weathers to light gray float, with few fossils. Fossils include brachiopod genera commonly referred to as <i>Hebertella</i> and <i>Rhynchotrema</i> . Shale, medium- to dark-gray, limy, in thin irregular laminae separating nodular limestone beds; minor dark-gray, thin, tabular beds. Unit weathers to orange-gray soil. Unit includes tongues of Brannon Member and Tanglewood Limestone Member.

RESOURCE: MacQuown, 1968.

**M&E**  
Metcalf & Eddy

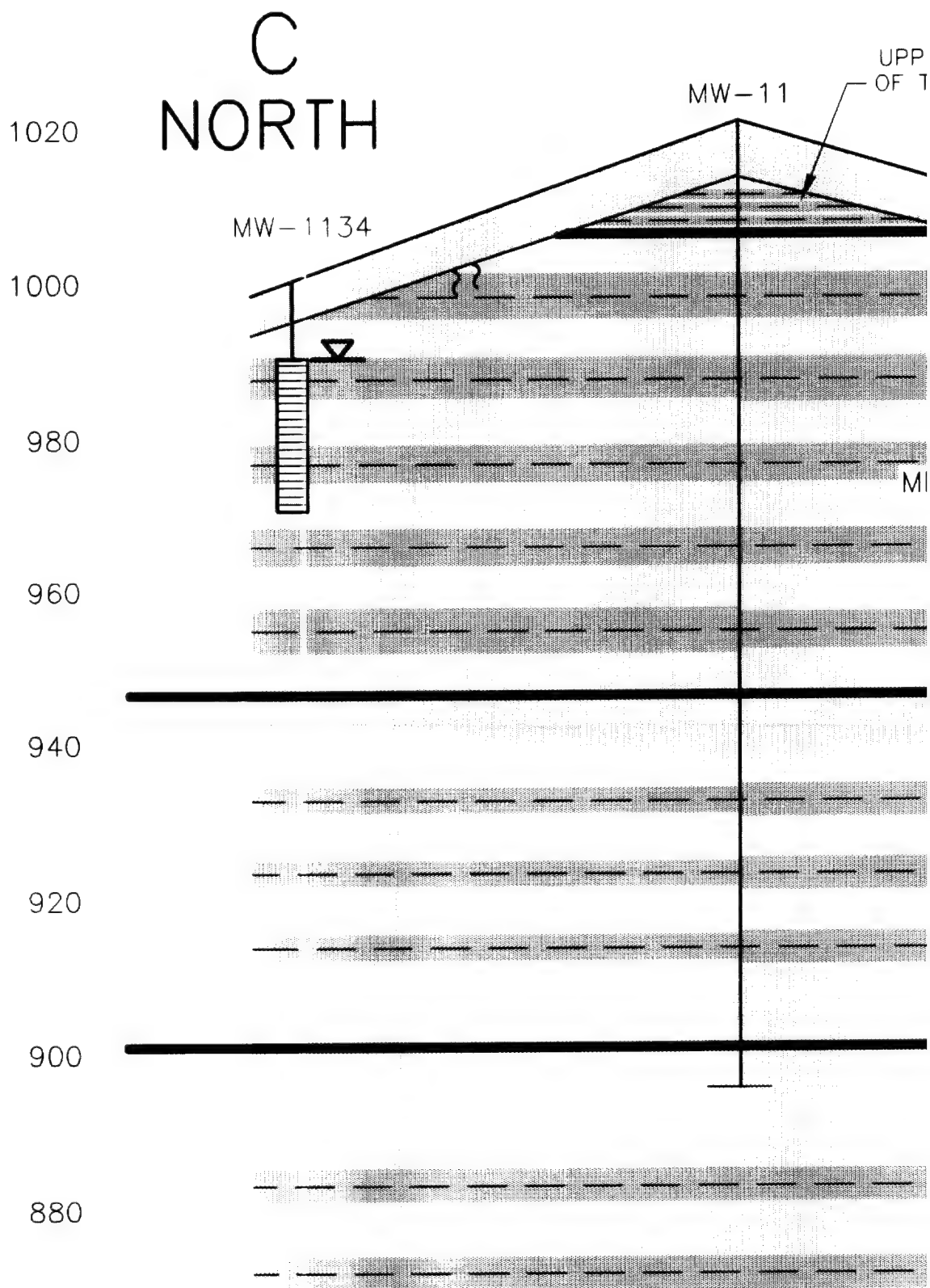
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GEOLOGICAL COLUMN  
LEXINGTON, KENTUCKY

Project Number  
012308

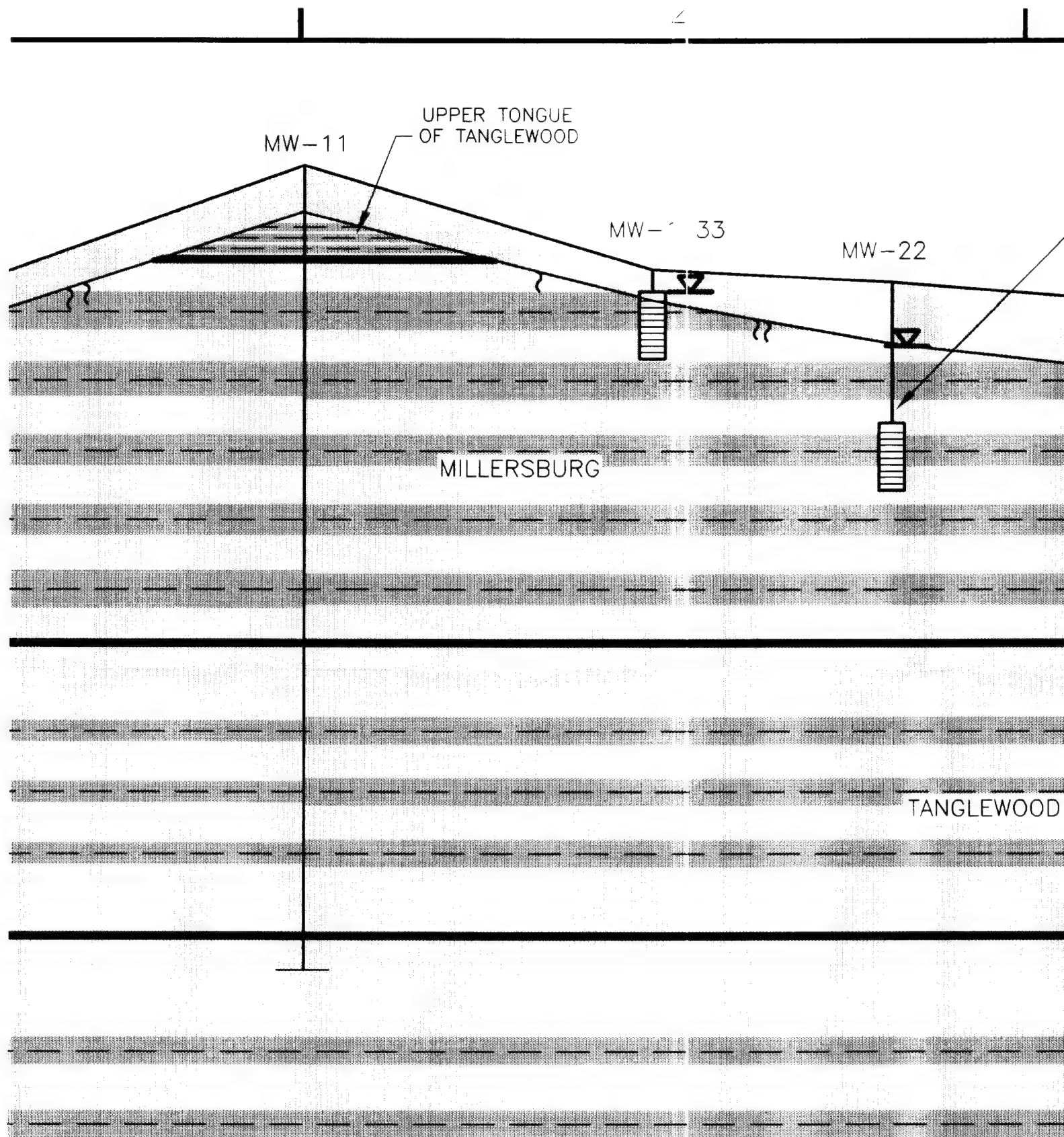
Figure  
3-1 (CONT.)

D

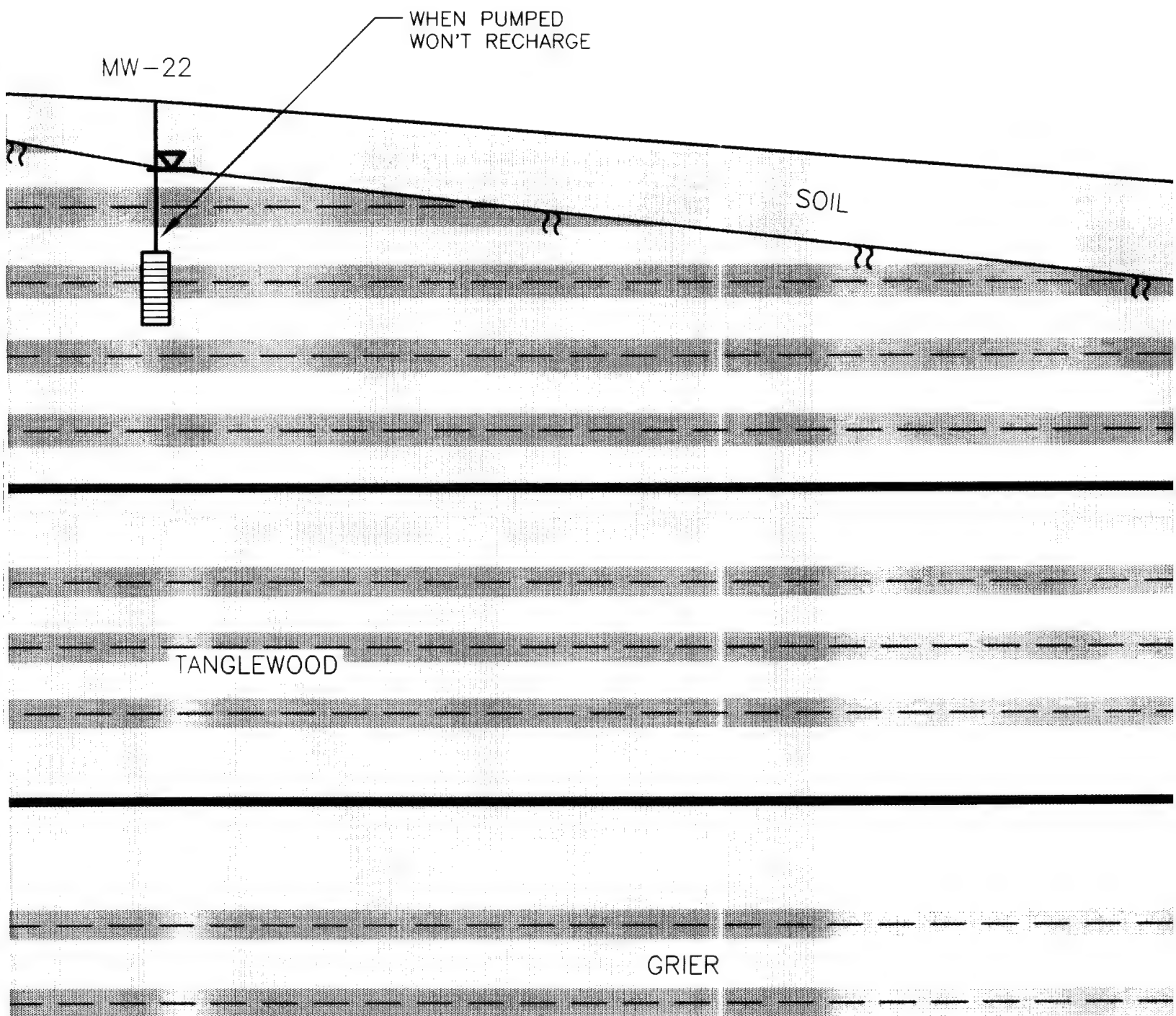
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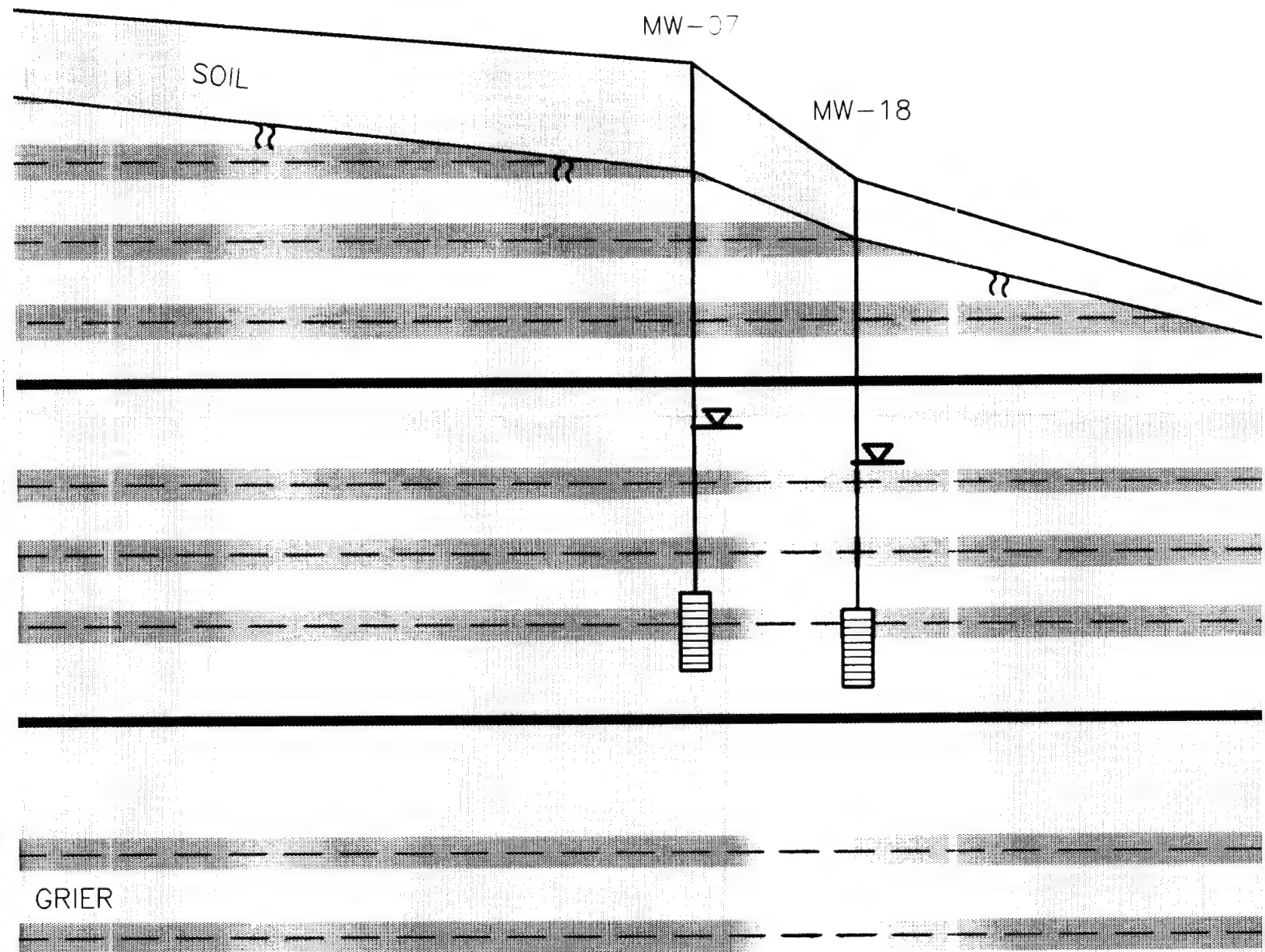


GEOLOGIC CROSS SECTION C-C'







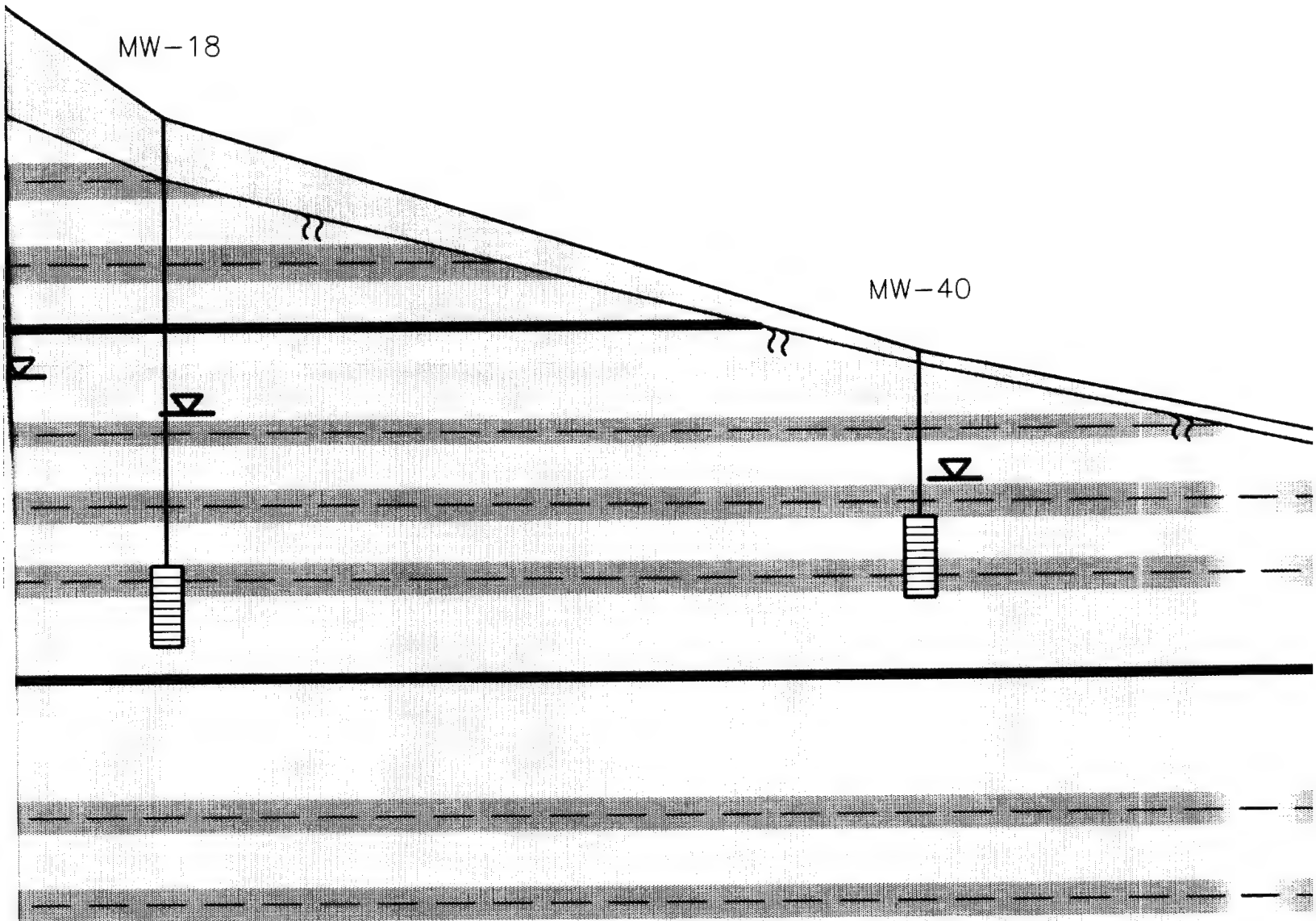


C'  
SOUTH

07

MW-18

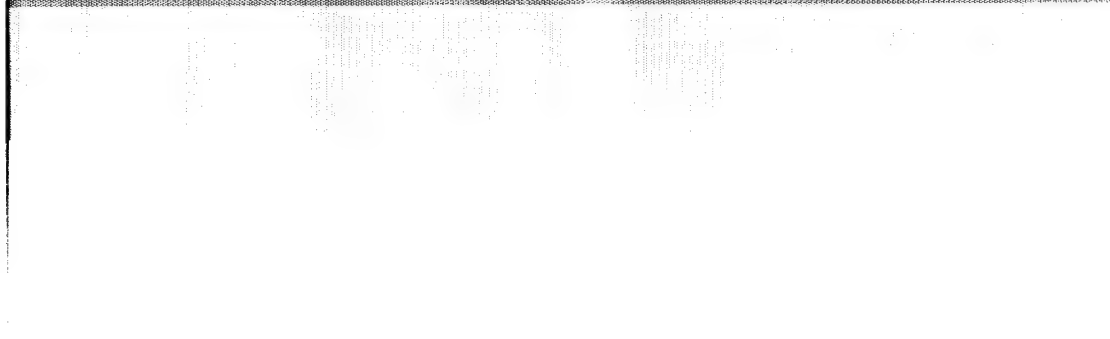
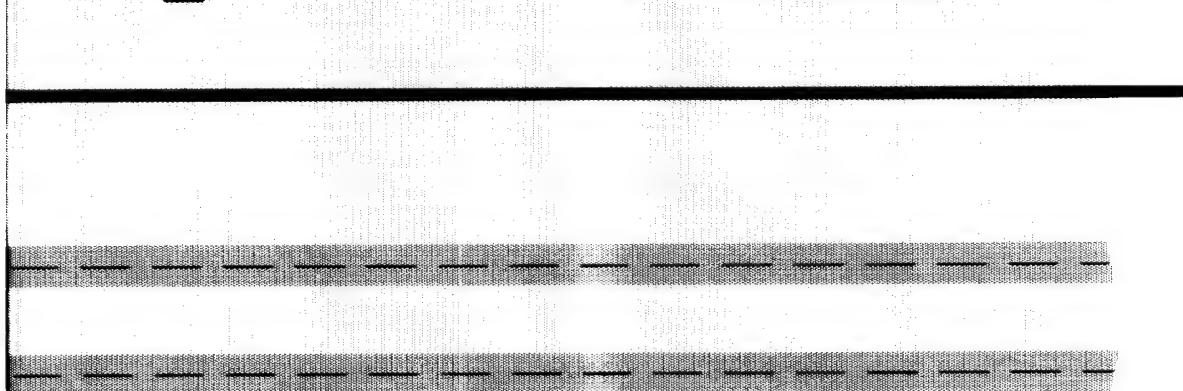
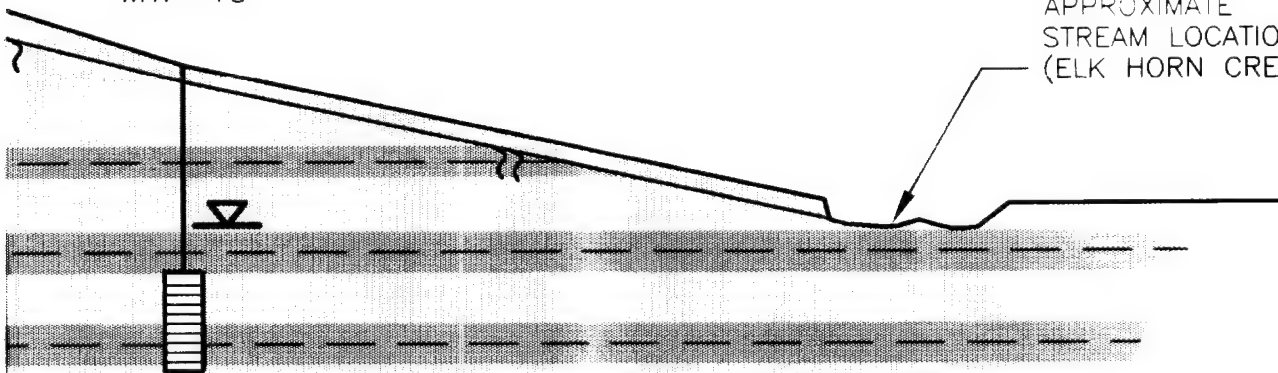
MW-40










# C' SOUTH

MW-40

APPROXIMATE  
STREAM LOCATION  
(ELK HORN CREEK TRIBUTARY)



-  LEAKAGE
-  WELL
-  POTENTIAL SURFACE
-  INFILTRATION
-  INFILTRATION FRACTURE
-  FRACTURE WATER STORAGE
-  LITHOLOGY

D

C

APPROXIMATE  
STREAM LOCATION  
(ELK HORN CREEK TRIBUTARY)

# LEGEND



WELL SCREEN



POTENTIOMETRIC  
SURFACE



INFERRED FRACTURES



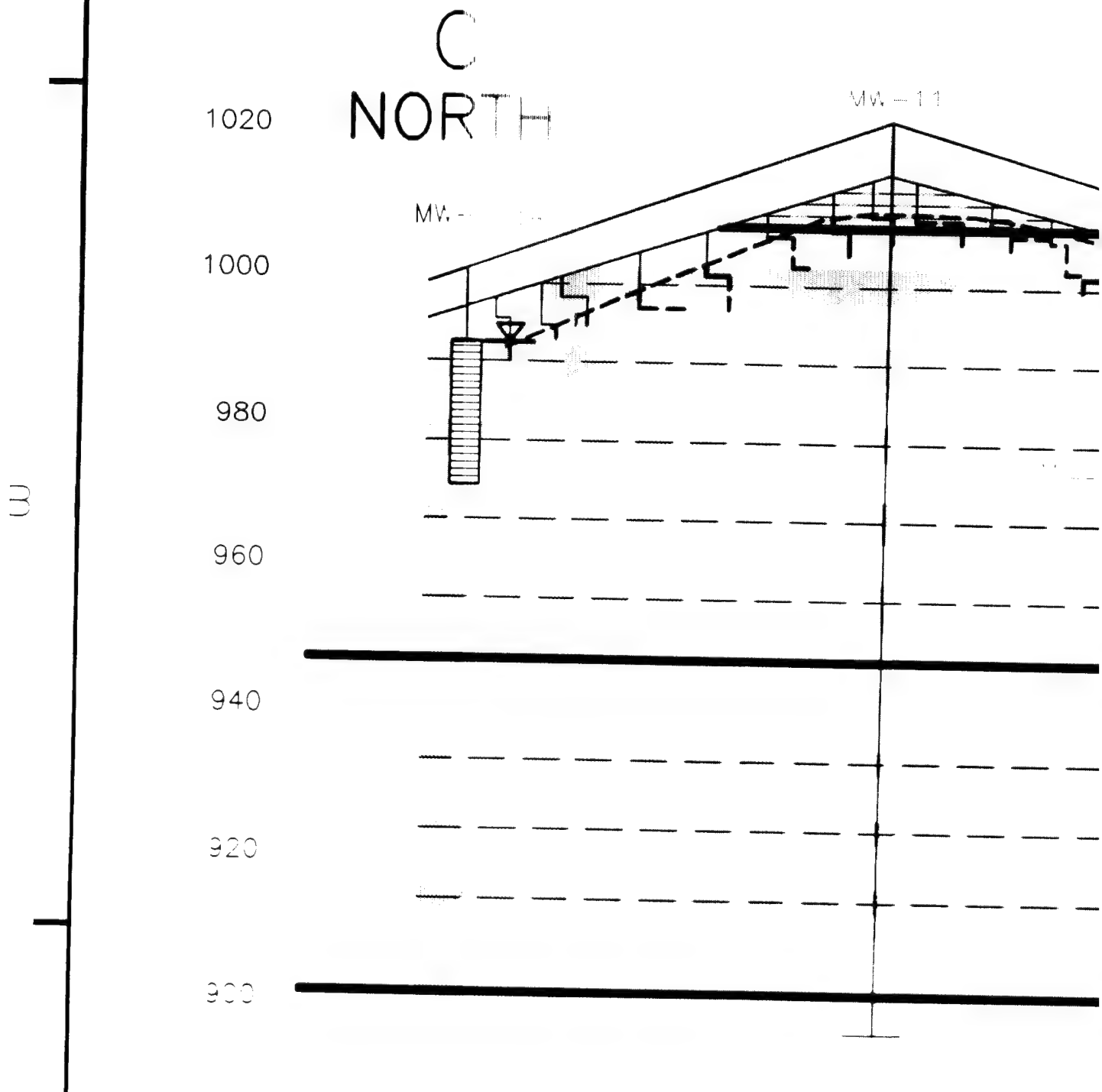
INFERRED WATER-FILLED  
FRACTURES



FRACTURE CONTAINING  
WATER ONLY DURING  
STORM CONDITIONS



LITHOLOGIC CONTACT

GEOLOGIC CROSS SECTION C-C'

SECTION C-C'

MW-11

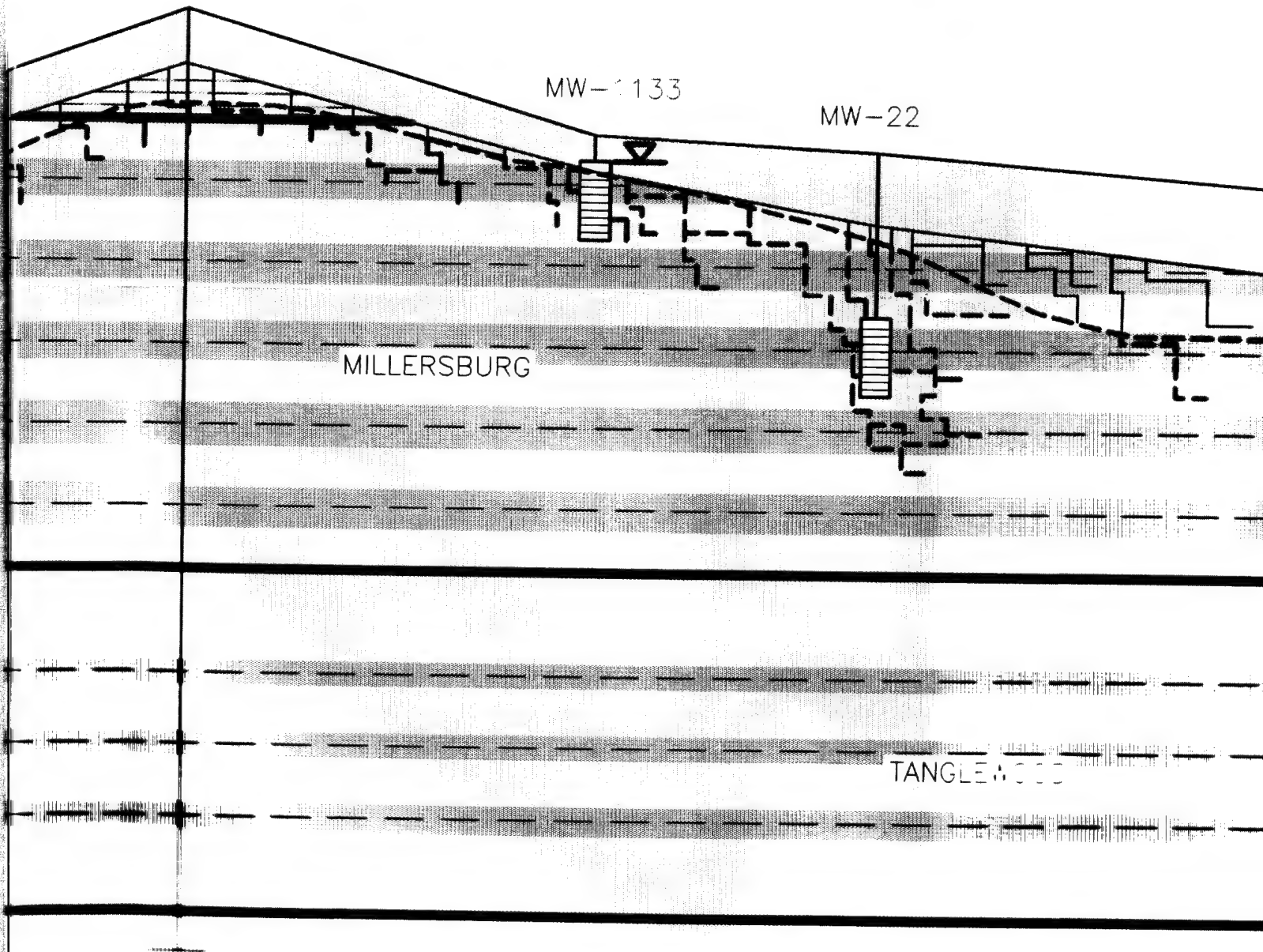
TOP OF ROCK FLOW

MW-1133

MW-22

MILLERSBURG

TANGLEWOOD





GRIER

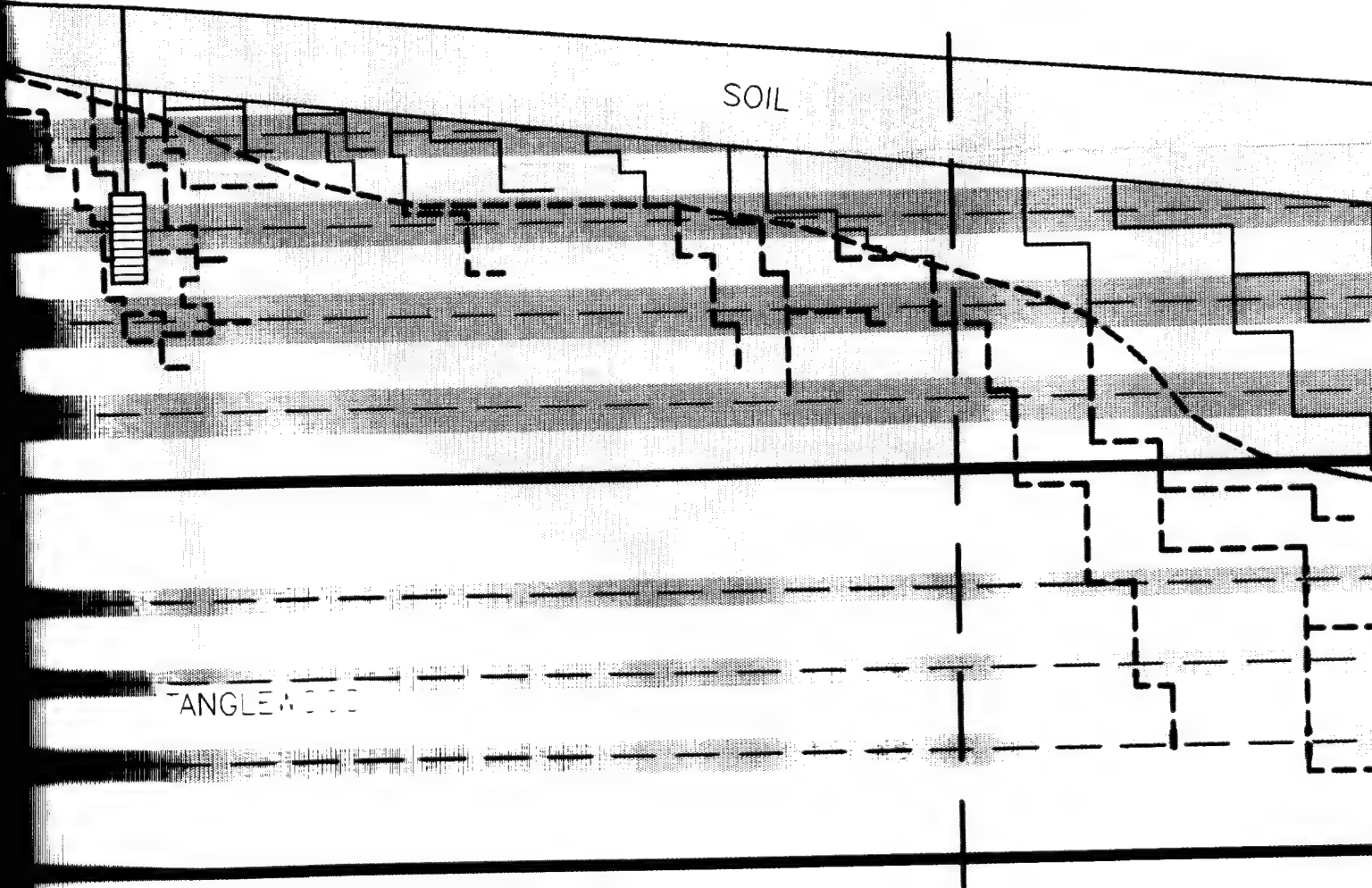
OF ROCK FLOW

W<sub>i</sub> -

MW-22

SOIL

ANGLE 000





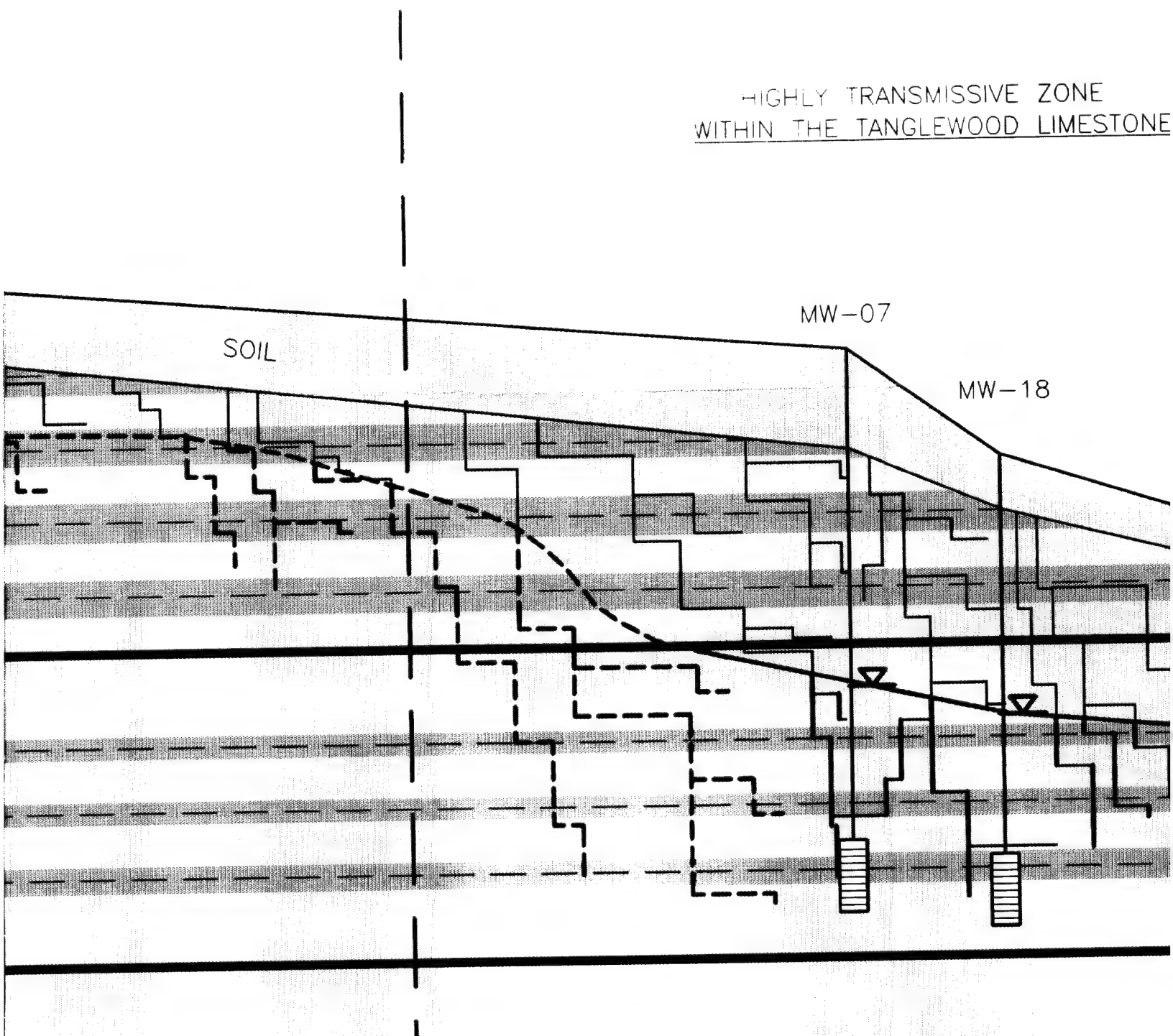
GRIER

HIGHLY TRANSMISSIVE ZONE  
WITHIN THE TANGLEWOOD LIMESTONE

MW-07

MW-18

SOIL



LY TRANSMISSIVE ZONE  
THE TANGLEWOOD LIMESTONE

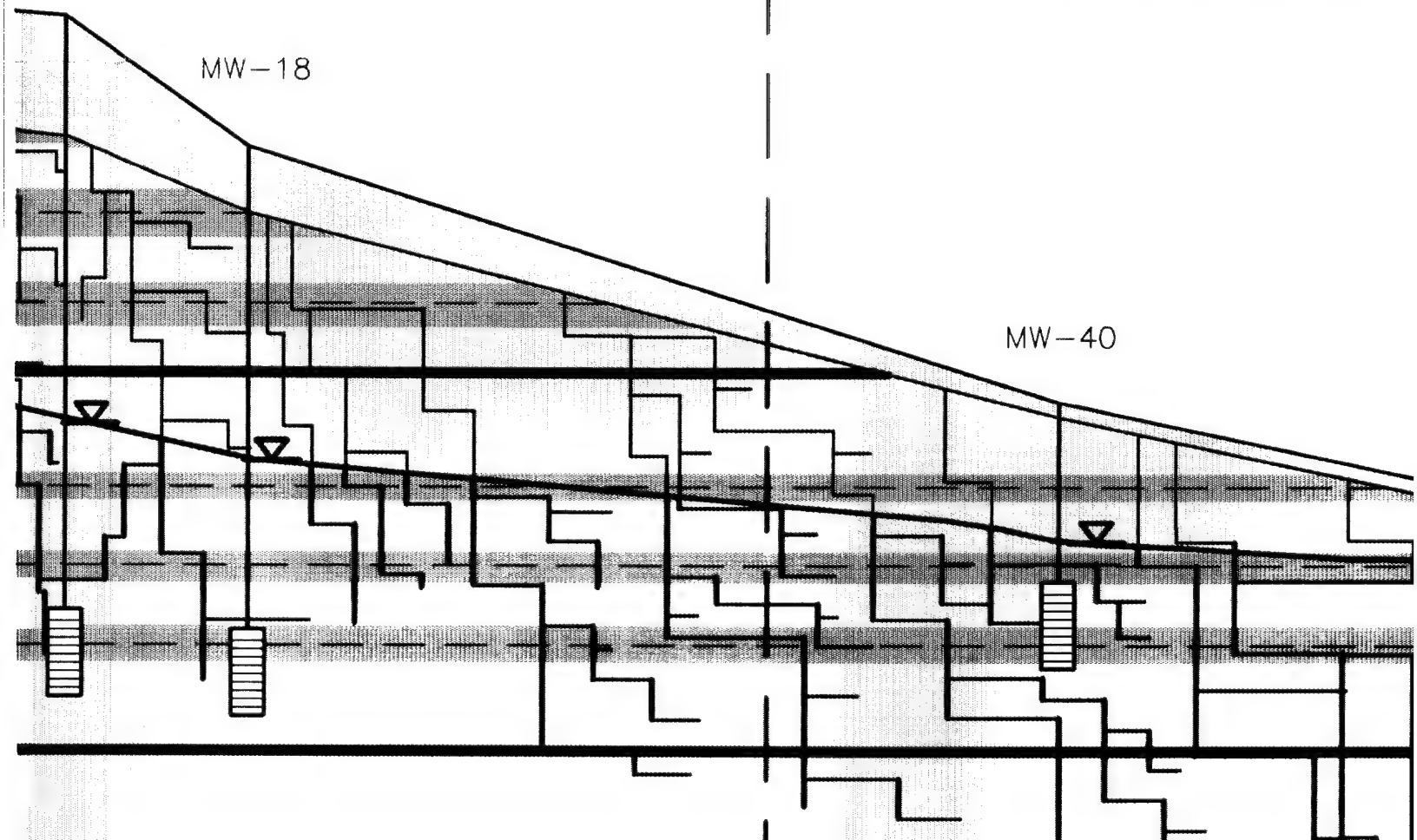
C'  
SOUTH

HIGHLY TRANSMISSIVE ZONE  
THE TANGLEWOOD AND THE GRI

MW-07

MW-18

MW-40



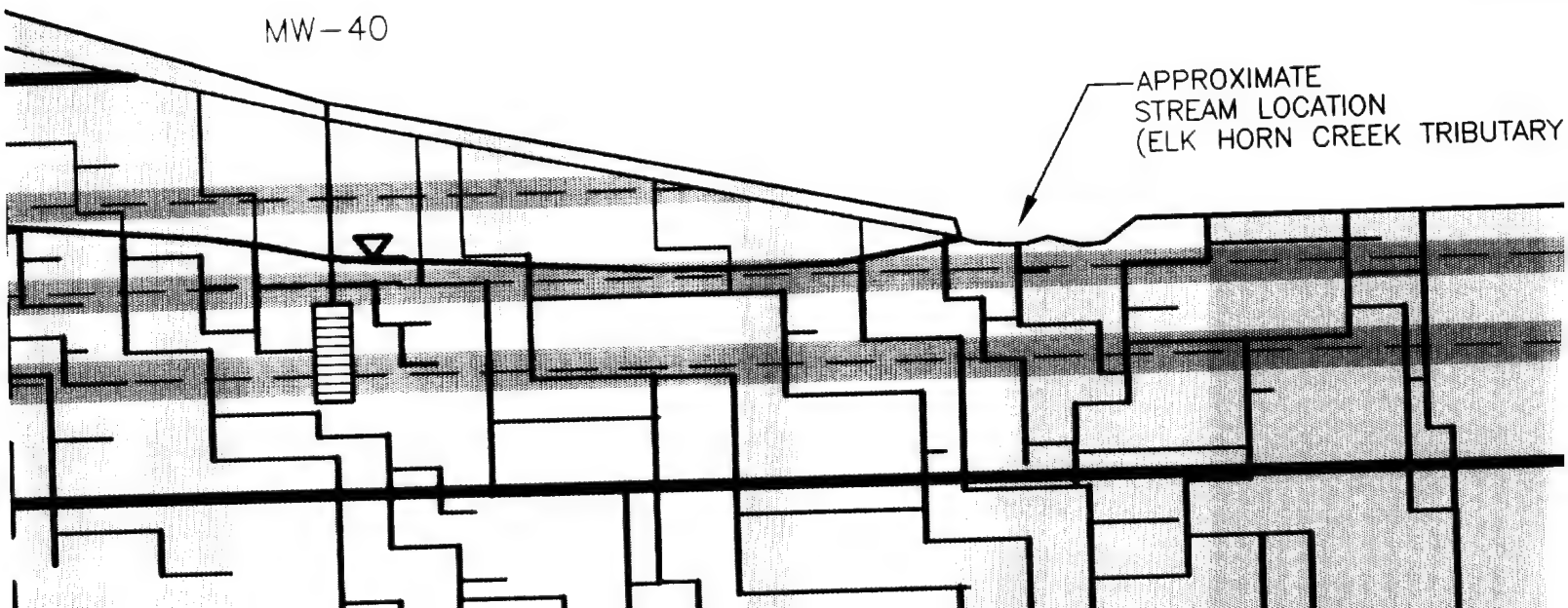
# C' SOUTH

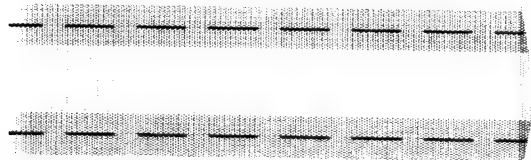
HIGHLY TRANSMISSIVE ZONE WITHIN  
THE TANGLEWOOD AND THE GRIER LIMESTONE



MW-40

APPROXIMATE  
STREAM LOCATION  
(ELK HORN CREEK TRIBUTARY)





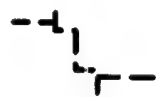
POTENTIOMETRIC SURFACE



INFERRED FRACTURES



INFERRED WATER-FILLED FRACTURES



FRACTURE CONTAINING WATER ONLY DURING STORM CONDITIONS



LITHOLOGIC CONTACT



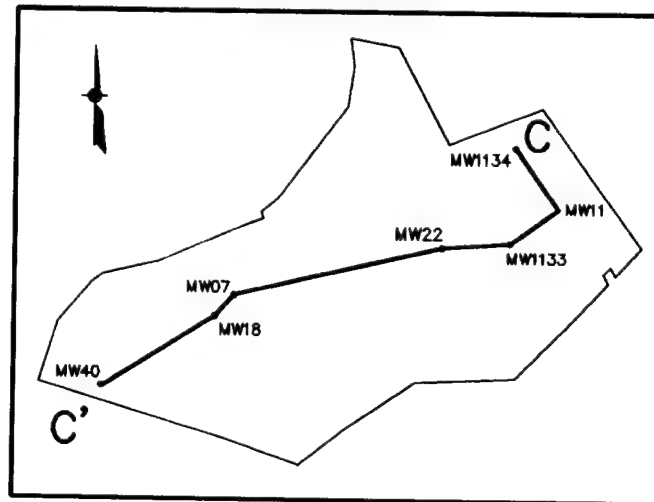
SHALE - 10% OF LITHOLOGIC UNIT

LIMESTONE



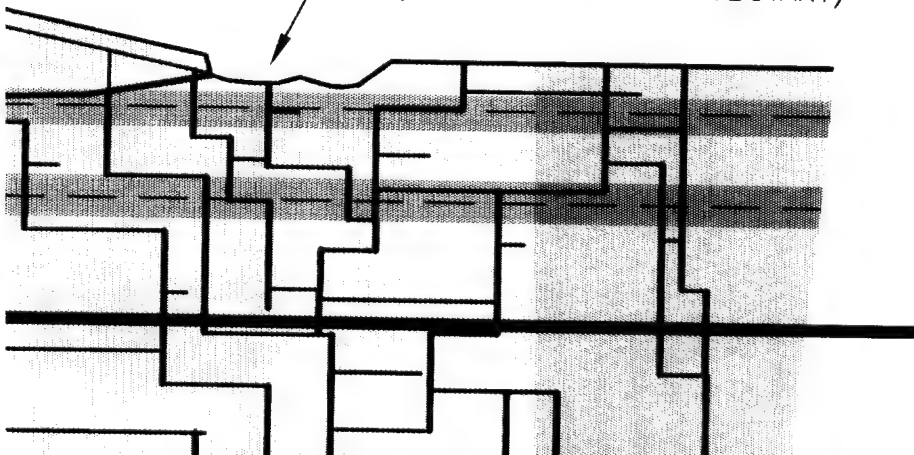
SOIL/BEDROCK INTERFACE

## SITE MAP



WITHIN  
LIMESTONE

APPROXIMATE  
STREAM LOCATION  
(ELK HORN CREEK TRIBUTARY)



B

980

MIL

960

940

920

900

880

A

# DEGREES OF AQUIFER DEVELOPMENT

NUMBER	DATE	MADE BY	CHECKED BY	DESCRIPTION
REVISIONS				

MILLERSBURG

TANGLEWOOD

## DEVELOPMENT

	DRAWN BY	
	CLF	
	DEPT. CHECK	
	PROJ. CHECK	
DESCRIPTION		
IONS		

TANGLEWOOD

GRIER

IN BY

CA<sup>3</sup>

CHECK

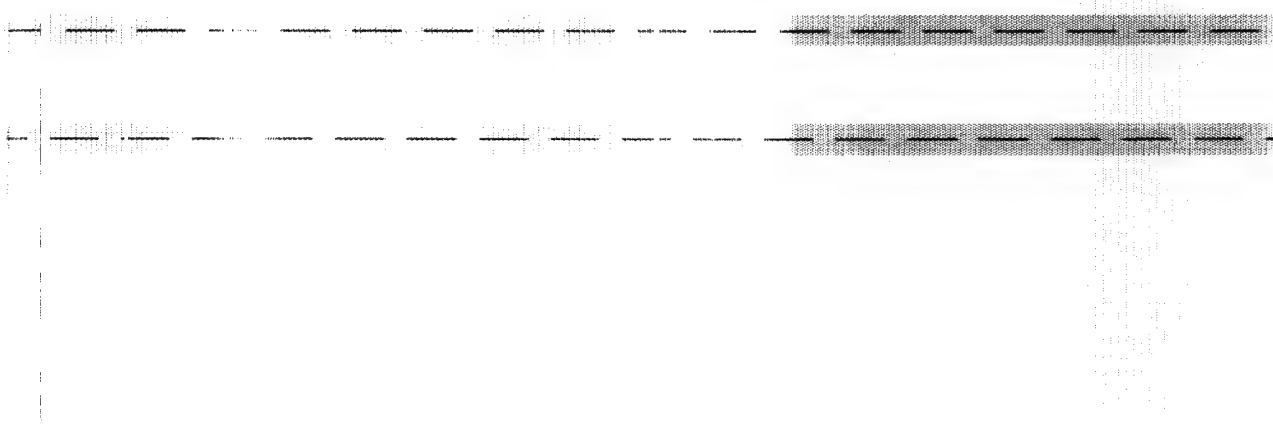
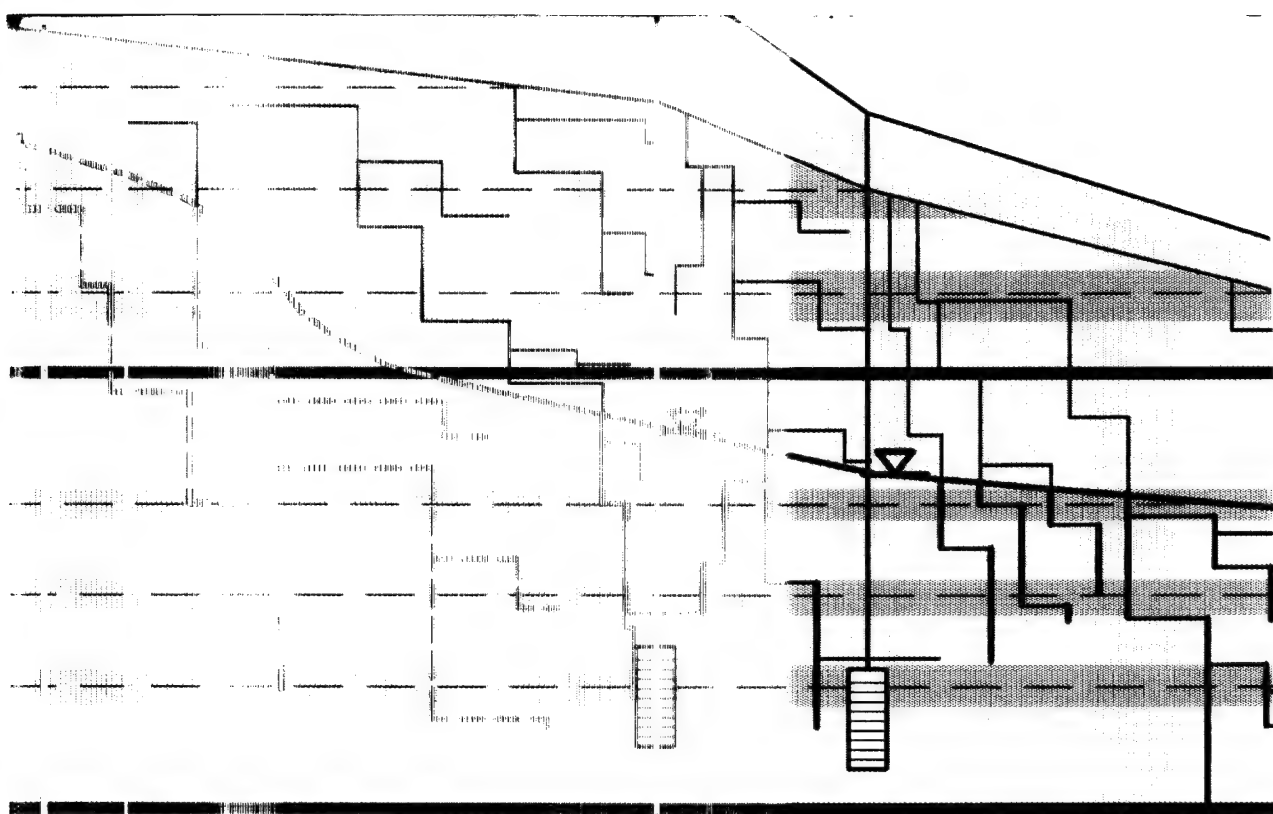
CHECK

**M&E**

Metcalfe

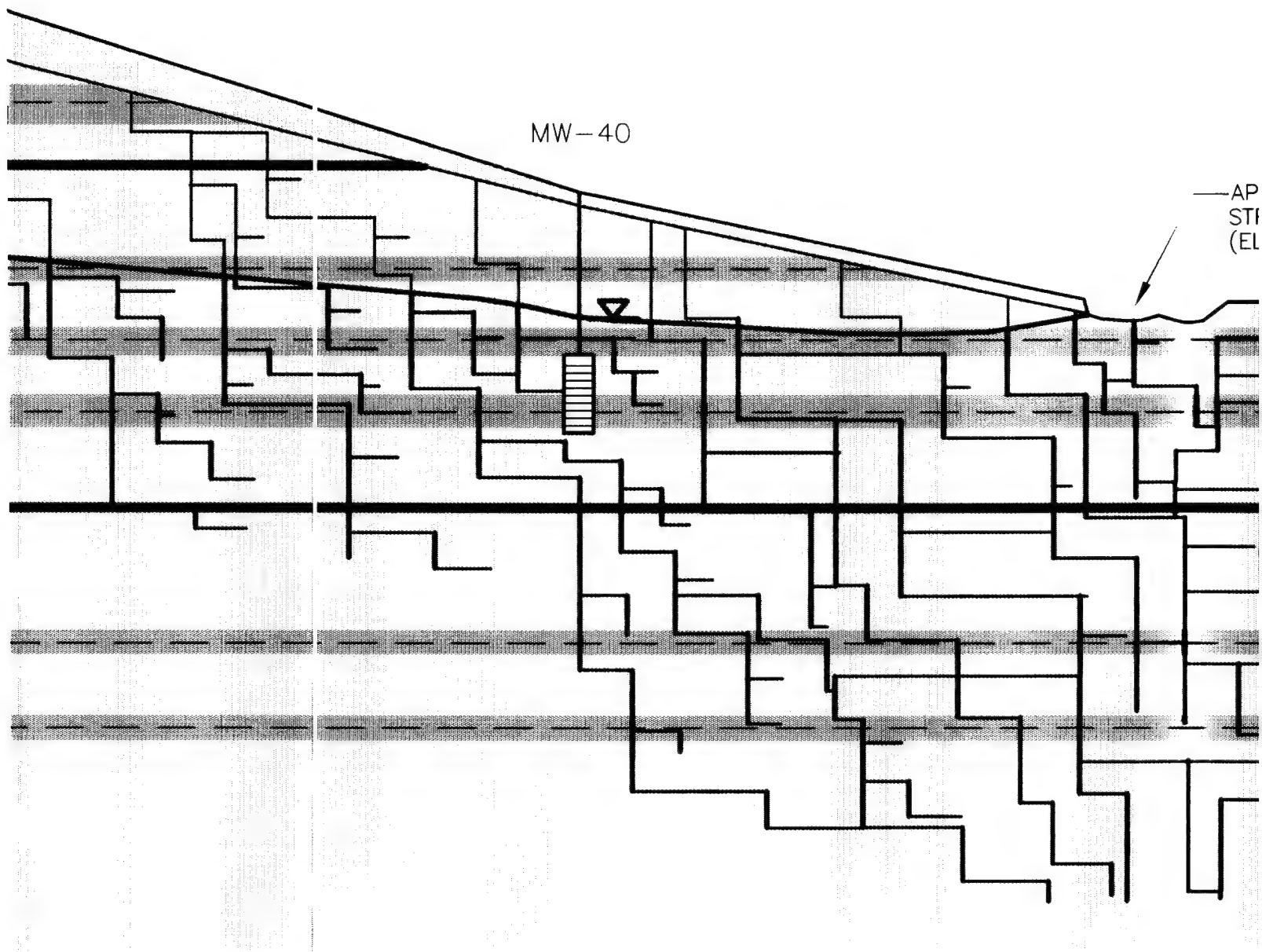
REG. PROF. ENGR.





	<h1>Metcalf &amp; Eddy</h1>	<p>VERTIC HORIZ</p>
<p>PROF ENGR</p>	<p>DATE</p>	<p>UNLESS OTHERWISE</p>

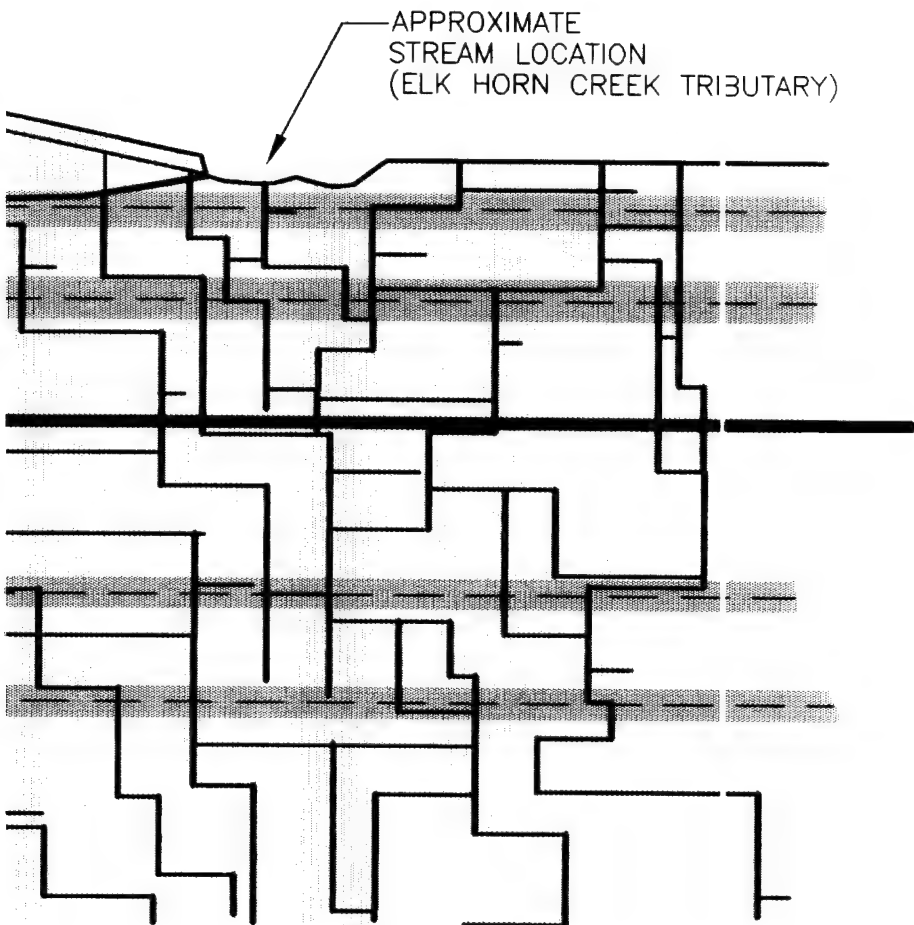
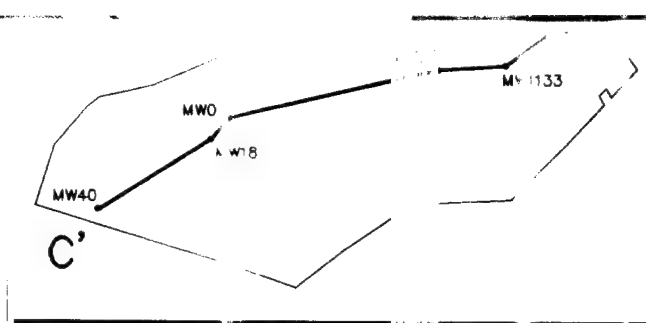




VERTICAL SCALE: 1" = 20'  
 HORIZONTAL SCALE: 1" = 437.44'

LEXINGTON BLUGRASS AR  
 GEOLOGIC CROSS SEC  
 LEXINGTON, KENTU

UNLESS OTHERWISE NOTED OR CHAIGED BY REPRODUCTION



LEXINGTON BLUGRASS ARMY DEPOT  
 GEOLOGIC CROSS SECTION C-C'  
 LEXINGTON, KENTUCKY

JOB \_\_\_\_\_ C12308-0006 \_\_\_\_\_

FILE NO. \_\_\_\_\_ MW-C \_\_\_\_\_

FIGURE \_\_\_\_\_ 3-2 \_\_\_\_\_

D  
EAST

CORE 1

1007' - 821.7'

1010 —

990 —

970 —

950 —

930 —

910 —

890 —

LS 20%  
SH 80%

LS 80%  
SH 20%

LS 20%  
SH 80%

LS 80%  
SH 20%

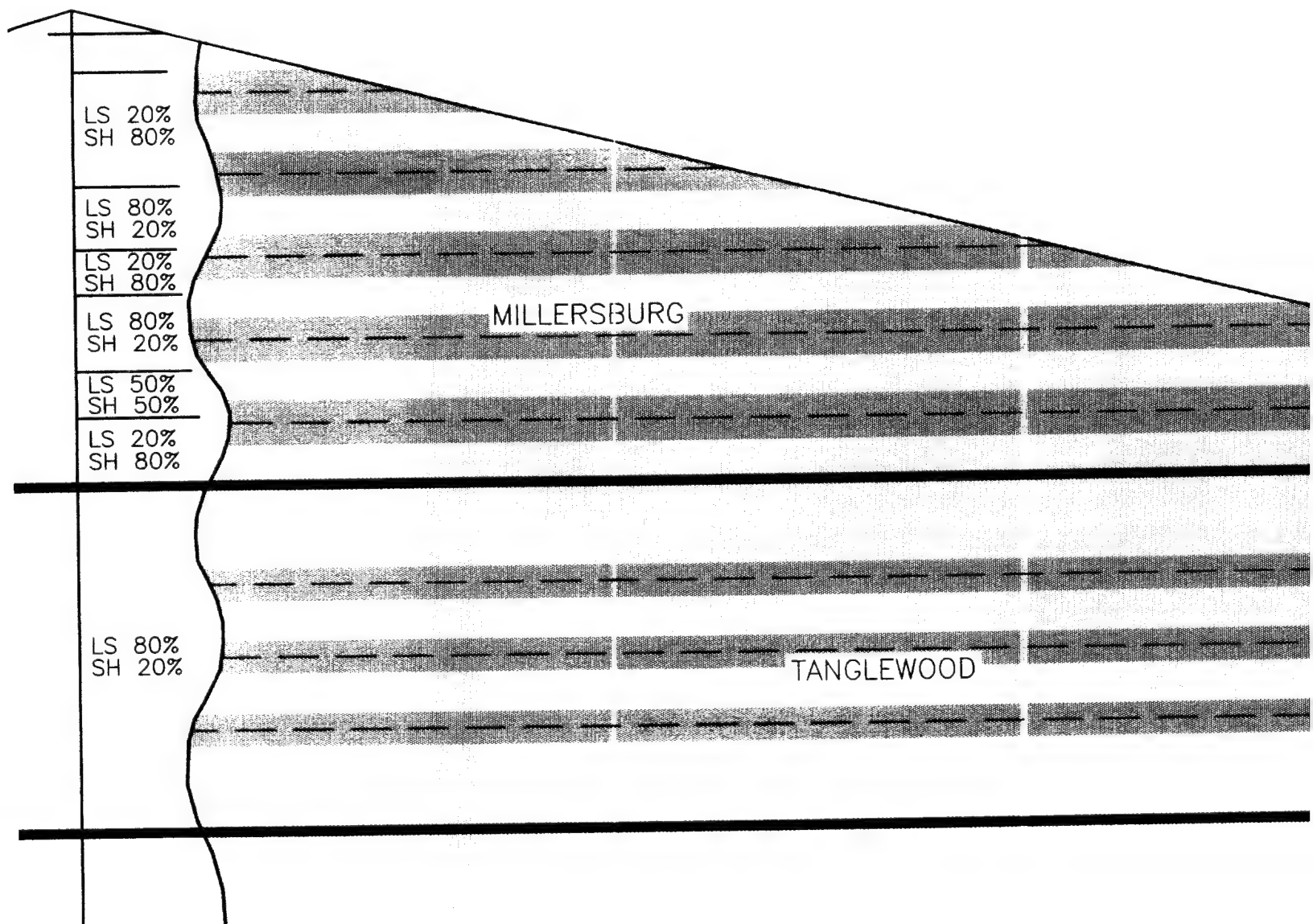
LS 50%  
SH 50%

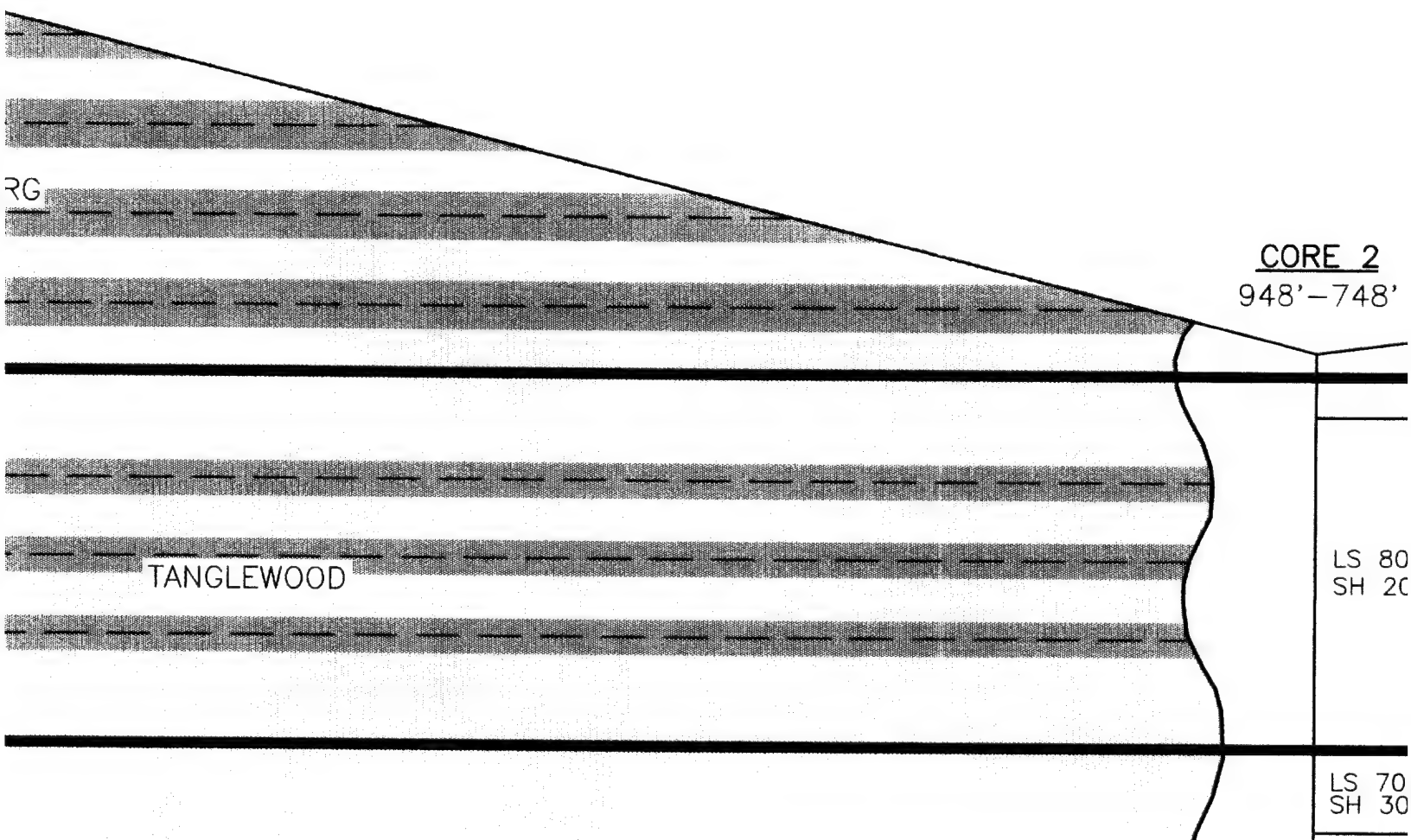
LS 20%  
SH 80%

LS 80%  
SH 20%

D  
EAST

CORE 1  
807'-821.7'





RG

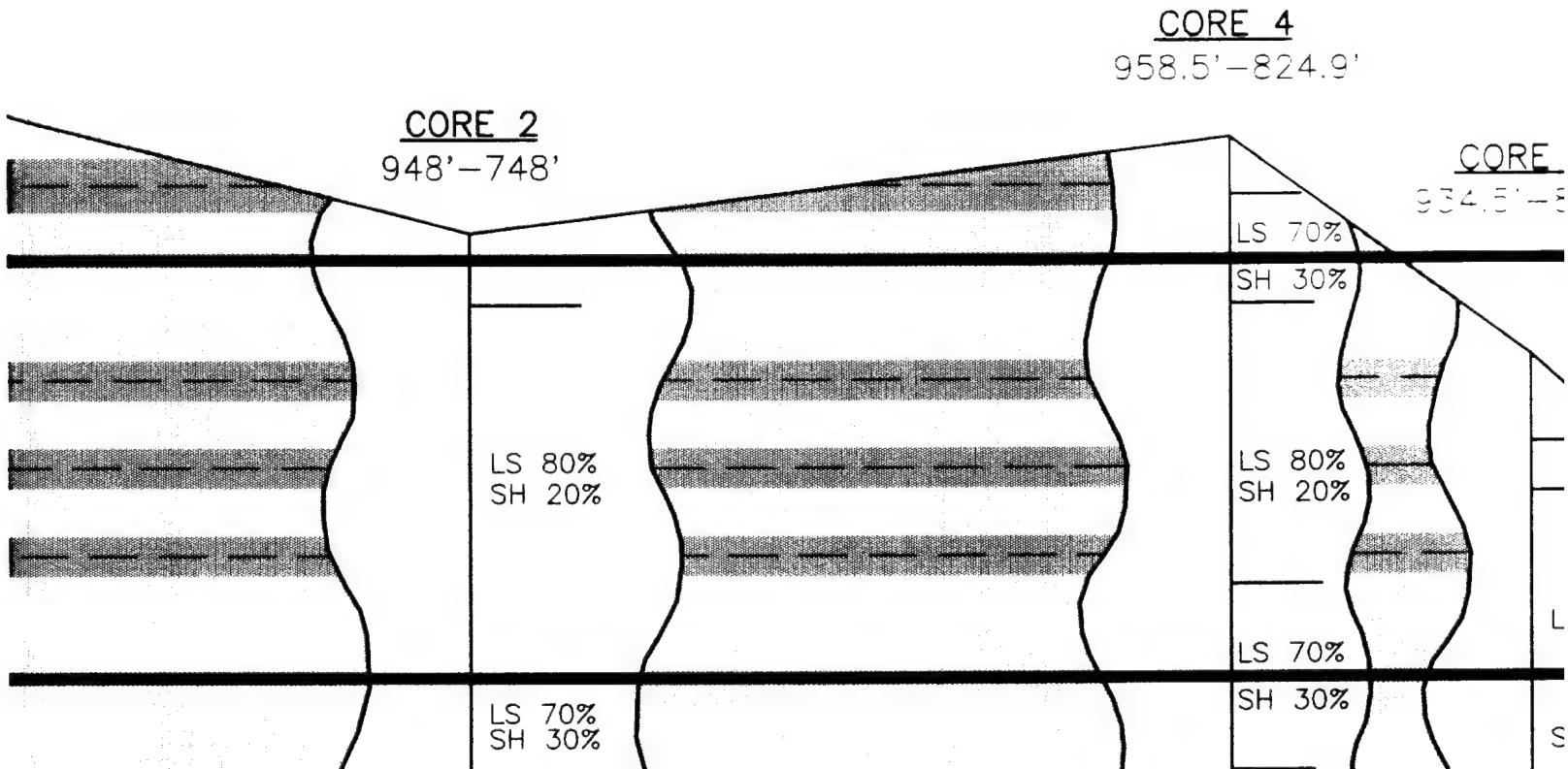
TANGLEWOOD

CORE 2  
948' - 748'

LS 80  
SH 20

LS 70  
SH 30

D  
WES



4

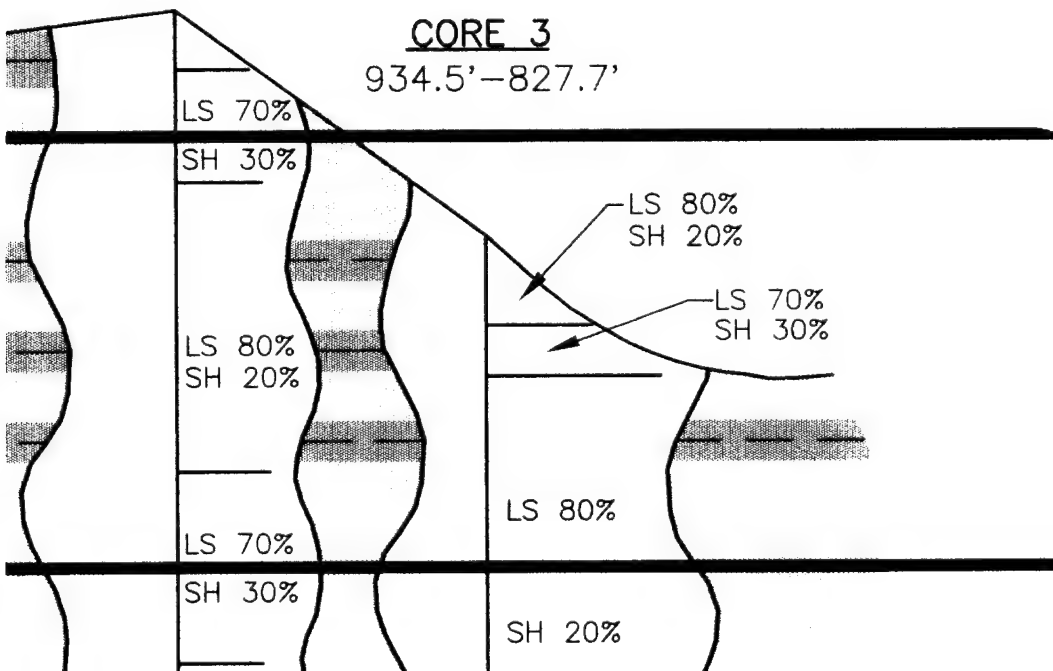
# D' WEST

## CORE 4

958.5'–824.9'

## CORE 3

934.5'–827.7'



∟

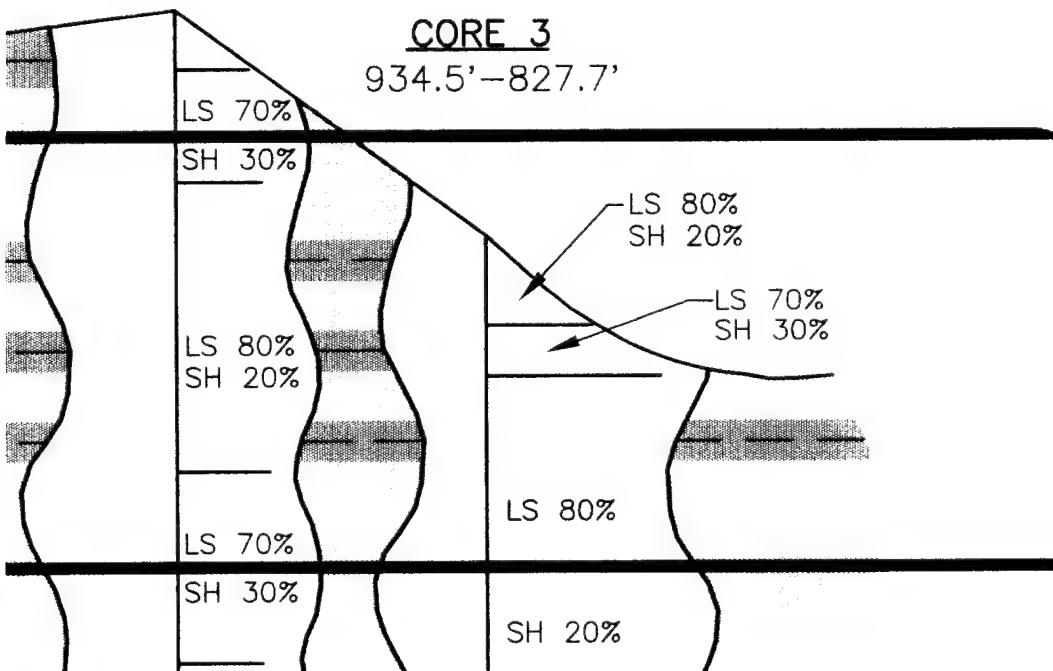
# D' WEST

## CORE 4

958.5'–824.9'

## CORE 3

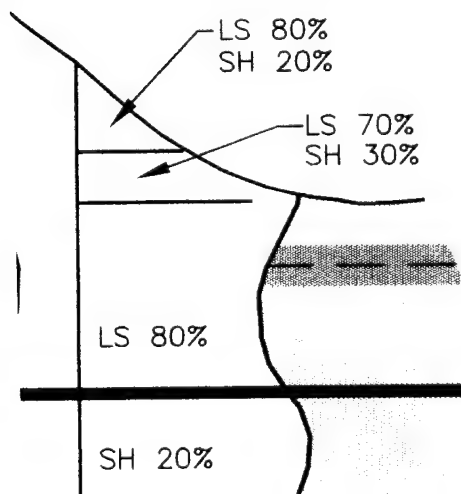
934.5'–827.7'





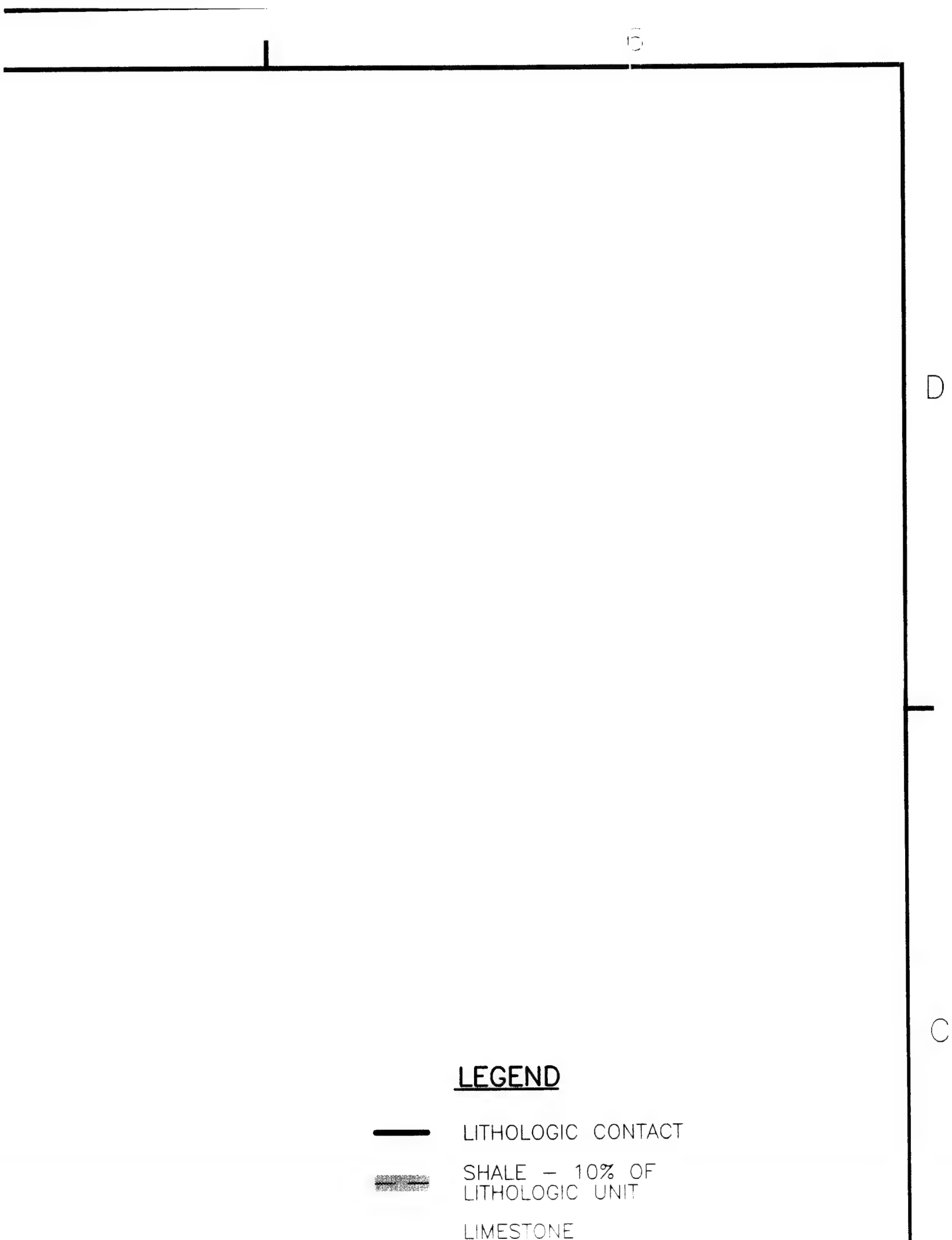
D'  
WEST

CORE 3  
4.5' - 827.7'



LEG

— LITHO  
- - SHALE  
- - LITHO  
- - LITHO



A

B

710 —

730 —

750 —

770 —

790 —

810 —

830 —

850 —

870 —

890 —

LS 70%  
SH 30%

LS 70%  
SH 30%

GRIER

HIGH BRIDGE 3F

LS 70%  
SH 30%

LS 65%  
SH 35%

LS 50%  
SH 50%

LS 60%  
SH 40%

LS 50%  
SH 50%

LS 70%  
SH 30%

LS 80%  
SH 20%

LS 60%  
SH 40%

LS 70%  
SH 30%

LS 50%  
SH 50%

LS 30%  
SH 70%

GRIER

HIGH BRIDGE GROUP

70%  
30%

65%  
35%

50%  
50%

60%  
40%

50%  
50%

70%  
30%

30%  
20%

10%  
10%

0%  
10%

1%  
1%  
0%  
0%

LS 70%  
SH 30%

LS 80%  
SH 20%

LS 65%  
SH 35%

LS 50%  
SH 50%

LS 70%  
SH 30%

LS 65%  
SH 35%

LS 80%

SH 20%

LS 70%  
SH 30%

LS 65%  
SH 35%

LS 70%  
SH 30%

LS 75%  
SH 25%

LS 80%

SH 20%

LS 70%  
SH 30%

LS 65%  
SH 35%

LS 70%  
SH 30%

LS 75%  
SH 25%

— LITHOL

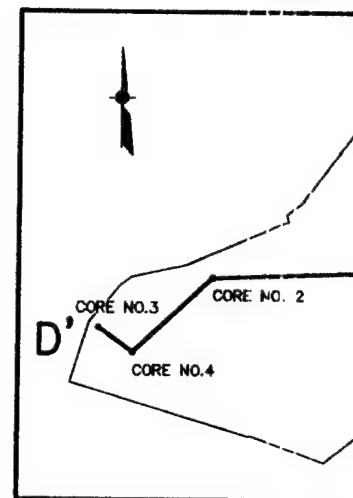
— SHALE  
LITHOL

LIMEST

LS 70% % LIM  
ROCK-

SH 30% % SHA  
ROCK-

SITE



— LITHOLOGIC CONTACT

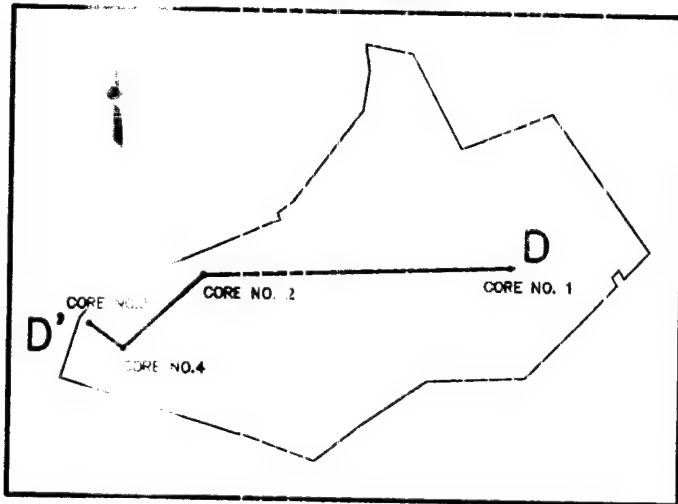
— SHALE — 10% OF  
LITHOLOGIC UNIT

LIMESTONE

LI % LIMESTONE IN  
ROCK-CORE INTERVAL

S % SHALE IN  
ROCK-CORE INTERVAL

### SITE MAP



B

A



B

810 —

790 —

770 —

750 —

730 —

710 —

A

NUMBER	DATE	MADE BY	CHECKED BY	DESCRIPTION		
REVISIONS						

HIGH BRIDGE GROUP

	DRAWN BY	
	CAP	
	DEPT. CHECK	
	PROJ. CHECK	
DESCRIPTION		

LS 80%  
SH 20%

LS 60%  
SH 40%

LS 70%  
SH 30%

LS 50%  
SH 50%

LS 30%  
SH 70%

HIGH BRIDGE GROUP

**M&E** Metcalf & Edd

REG. PROF. ENGR.

LS 80%  
SH 20%

LS 60%  
SH 40%

LS 70%  
SH 30%

LS 50%  
SH 50%

LS 30%  
SH 70%

LS 55%  
SH 35%

LS 70%  
SH 25%

**Metcalf & Eddy**

VERTICAL SCALE: 1" = 20'  
HORIZONTAL SCALE: 1" = 437.44'

DATE

UNLESS OTHERWISE NOTED OR CHANGED BY REPRODUCTION

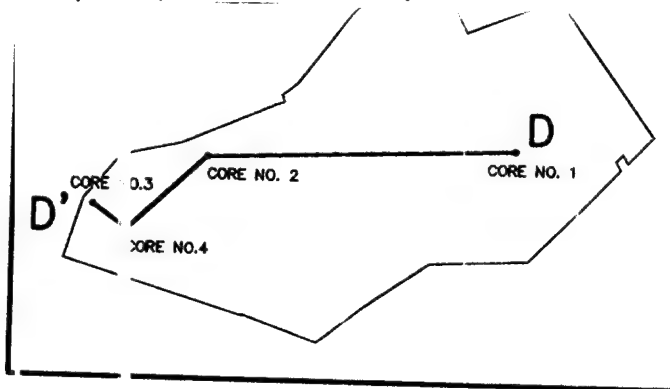
25%

D' CORE NO. 3 CORE NO. 2 CORE NO. 4

SCALE: 1" = 20'  
SCALE: 1" = 437.44'

CHANGED BY REPRODUCTION

LEXINGTON BLUGRASS ARMY DEPOT  
ROCK CORE CROSS SECTION  
LEXINGTON, KENTUCKY



LEXINGTON BLUGRASS ARMY DEPOT  
ROCK CORE CROSS SECTION  
LEXINGTON, KENTUCKY

JOB 012308-0006

FILE NO. CORE-XS

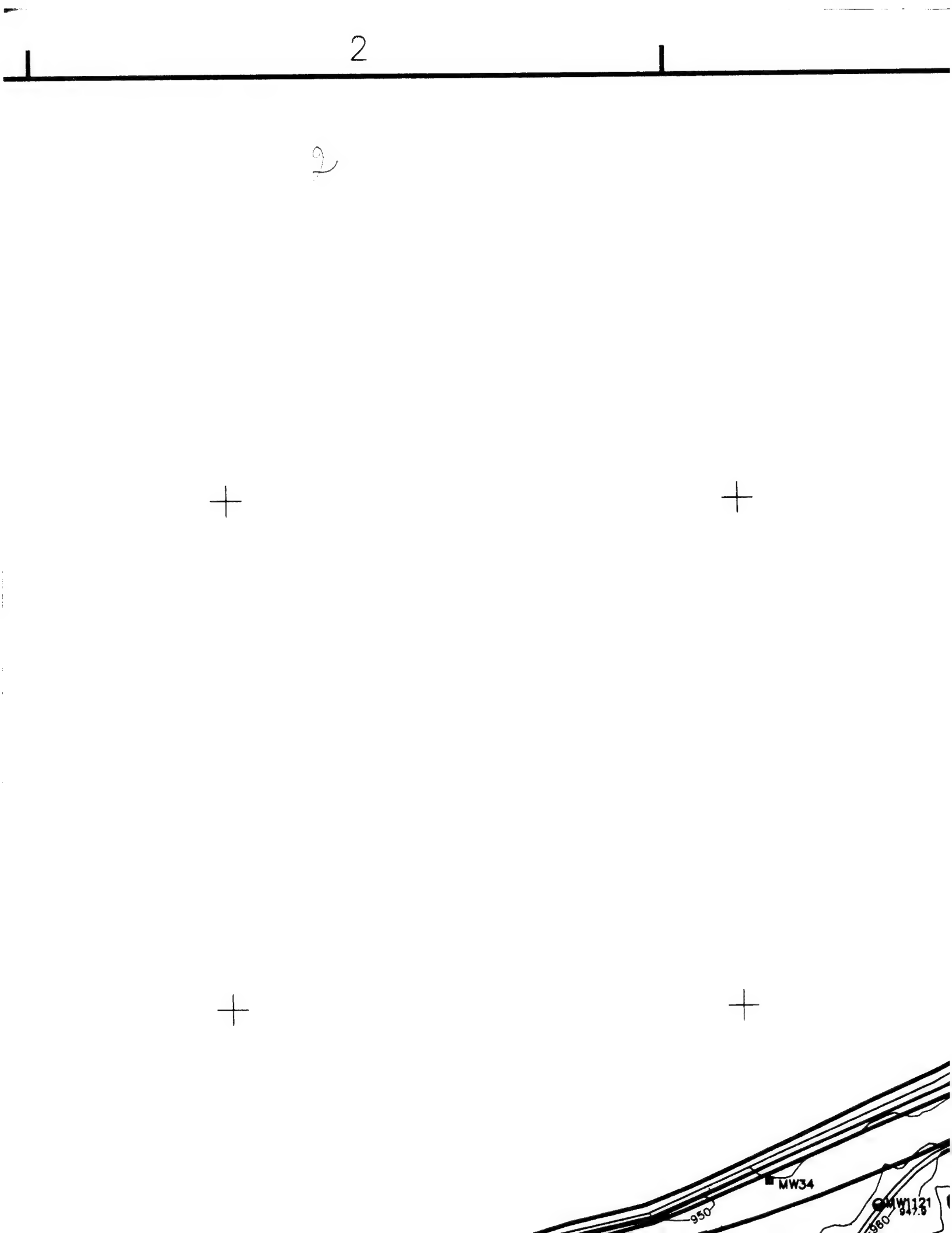
FIGURE 3-3

D

13,842,000N

2,406,000E

C





2

3

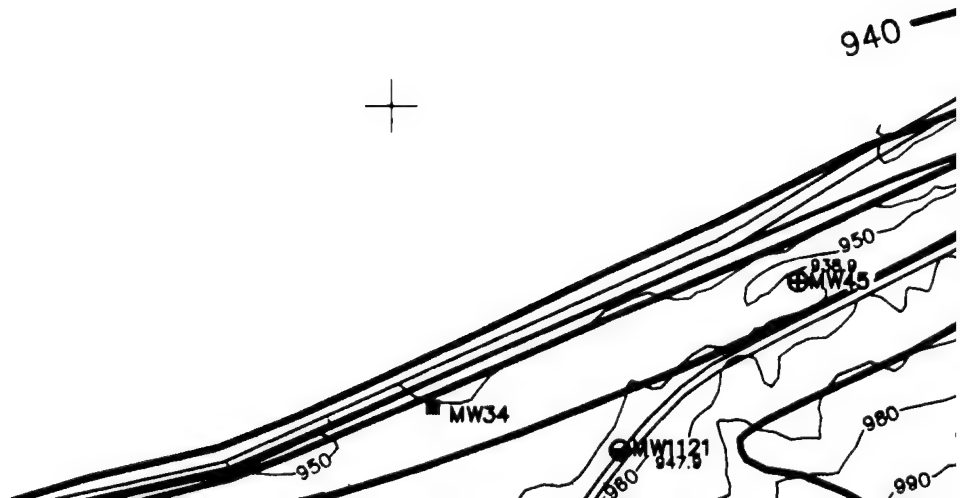
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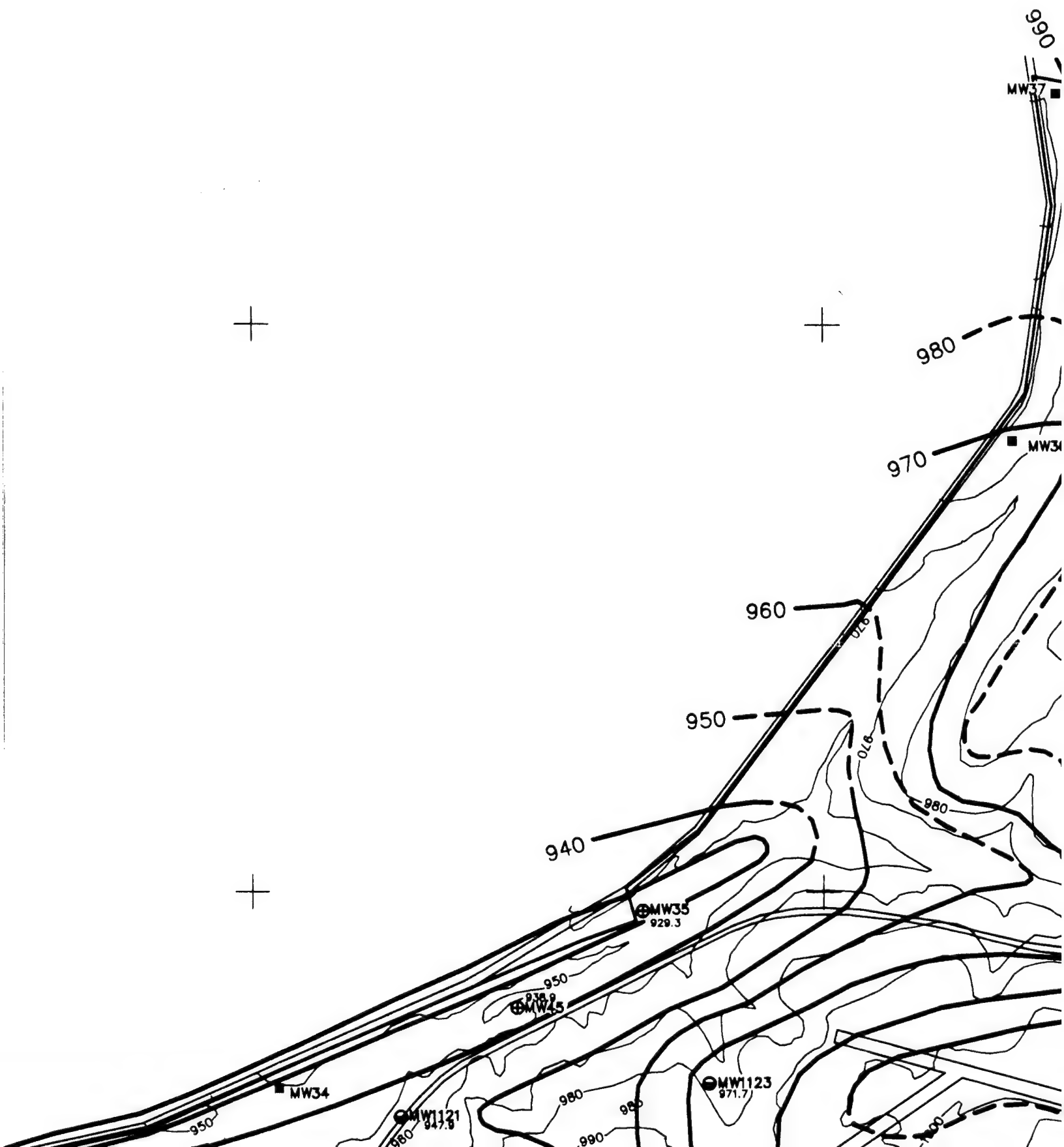
+

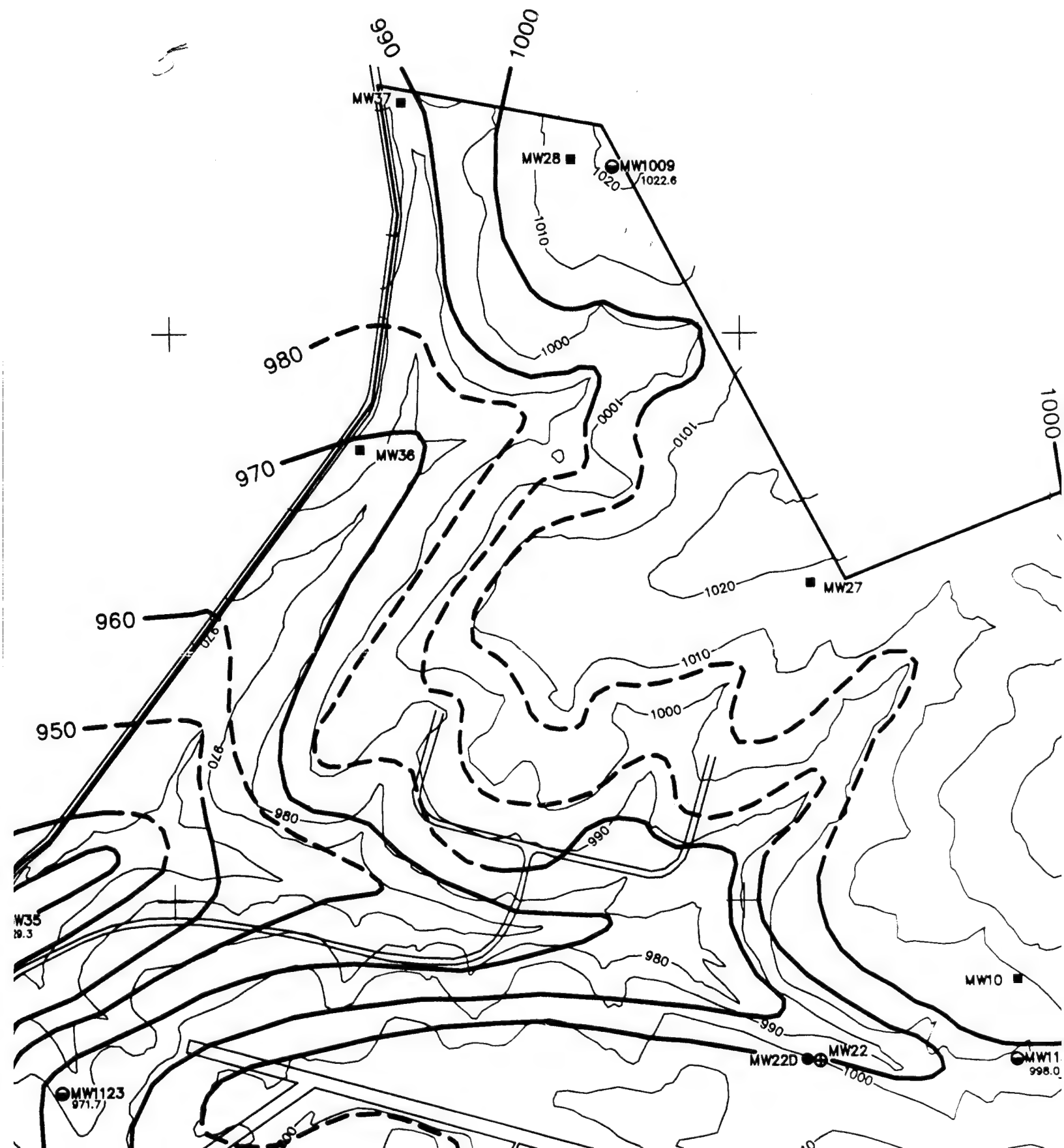
+

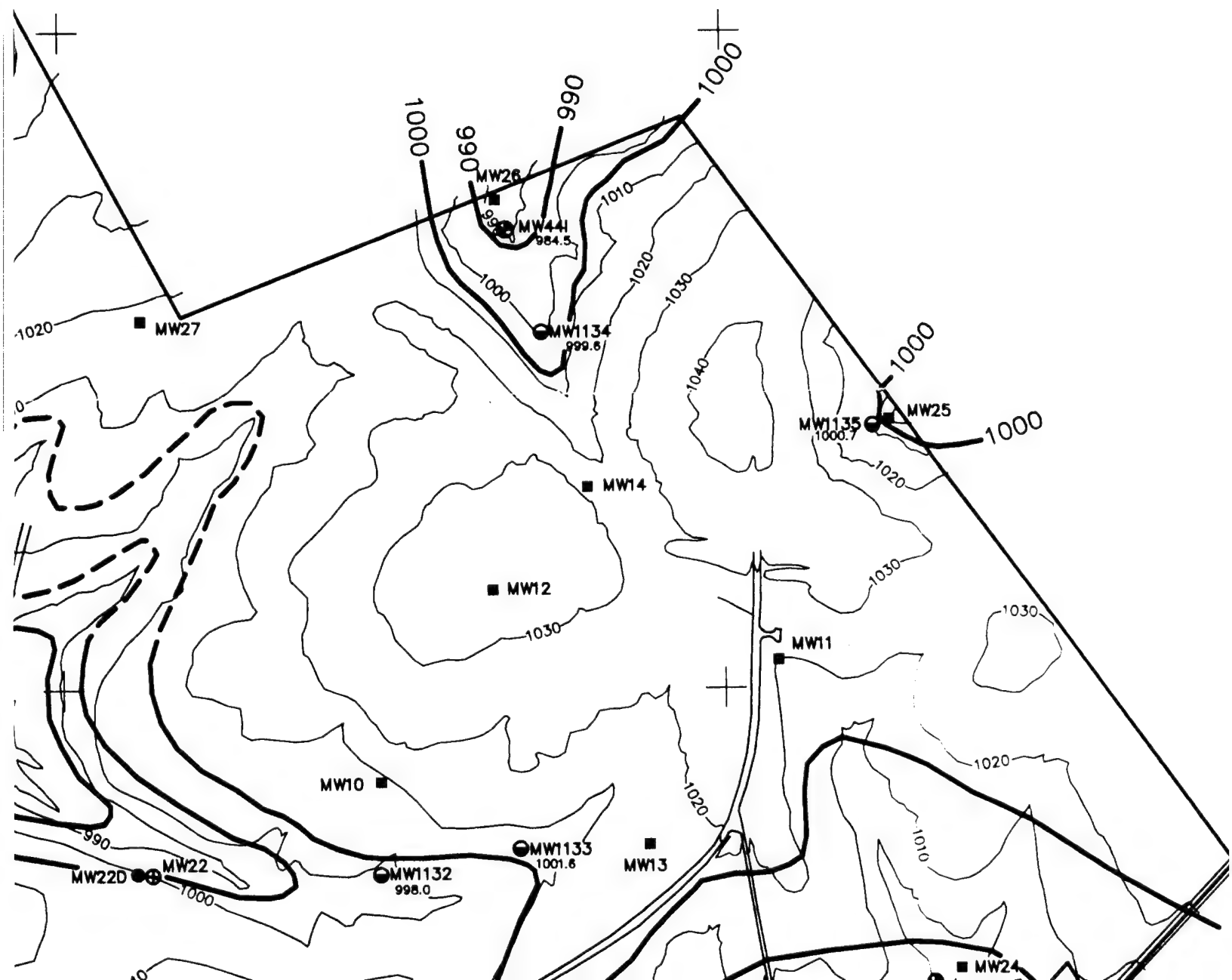
+

+





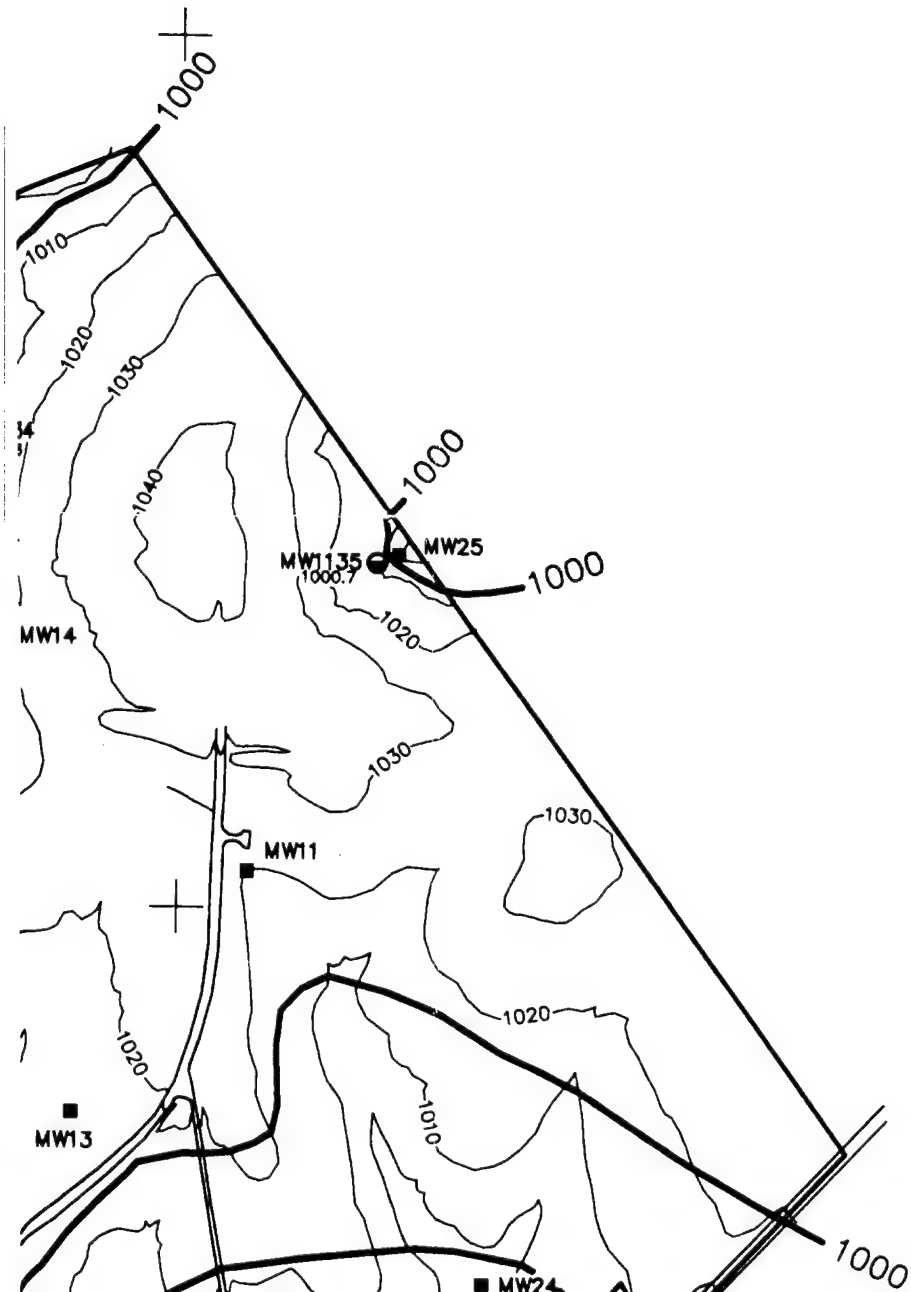






2,418,000E

13,842,000N

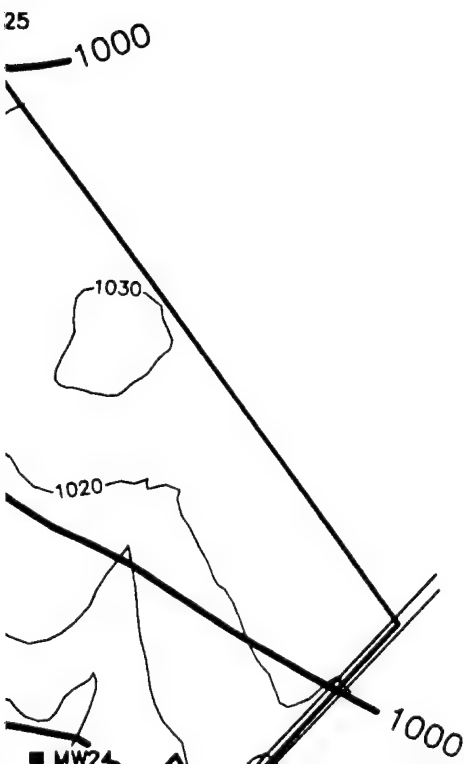




2,418,000E  
13,842,000N

D

C



8

C

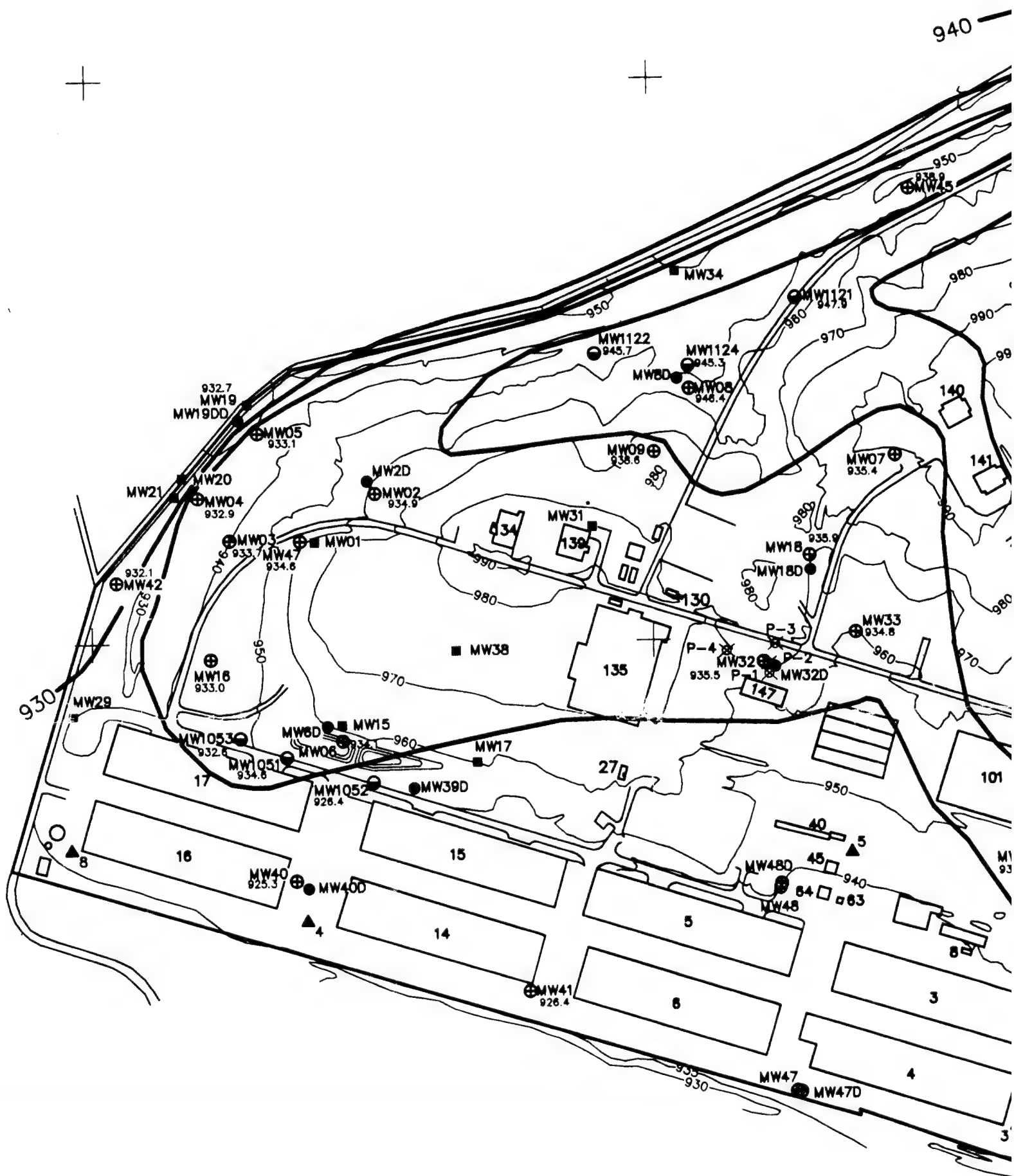
B

13.836.000N

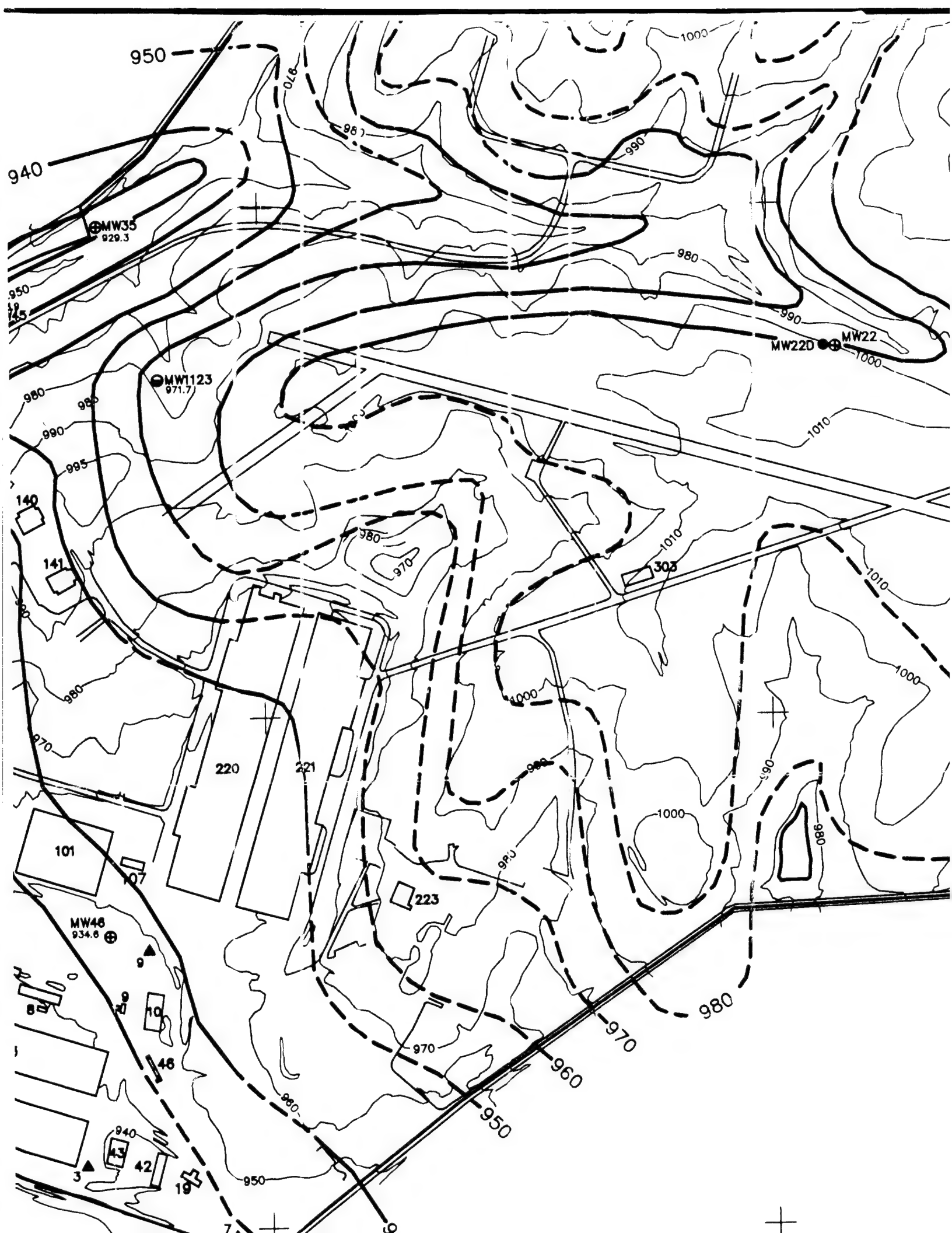
2,406,000E

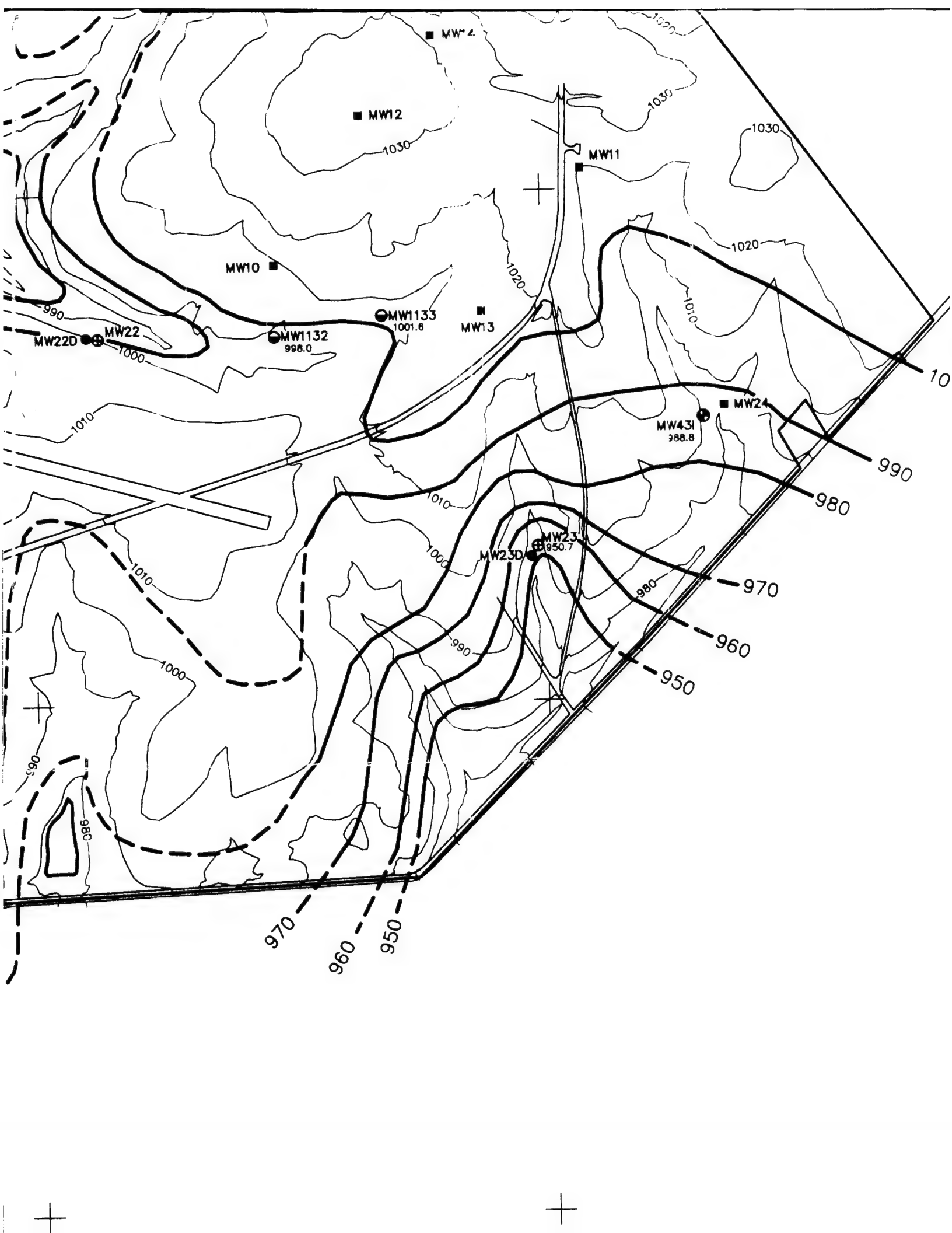
LEGEND

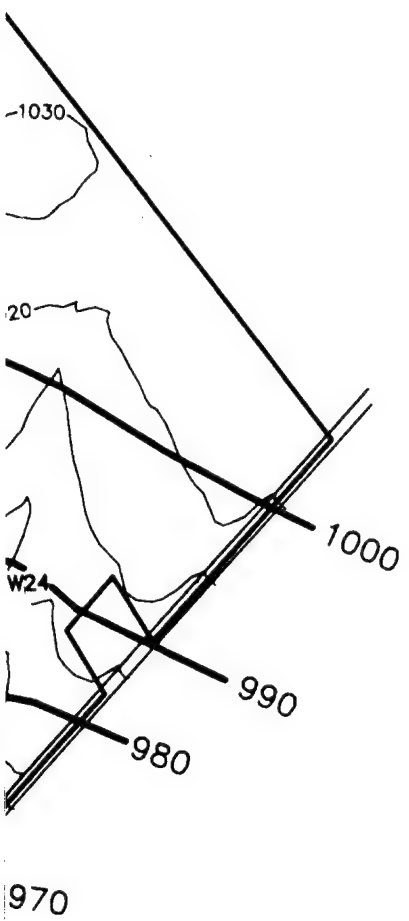












C

B

2,418,000E

13,836,000N

C

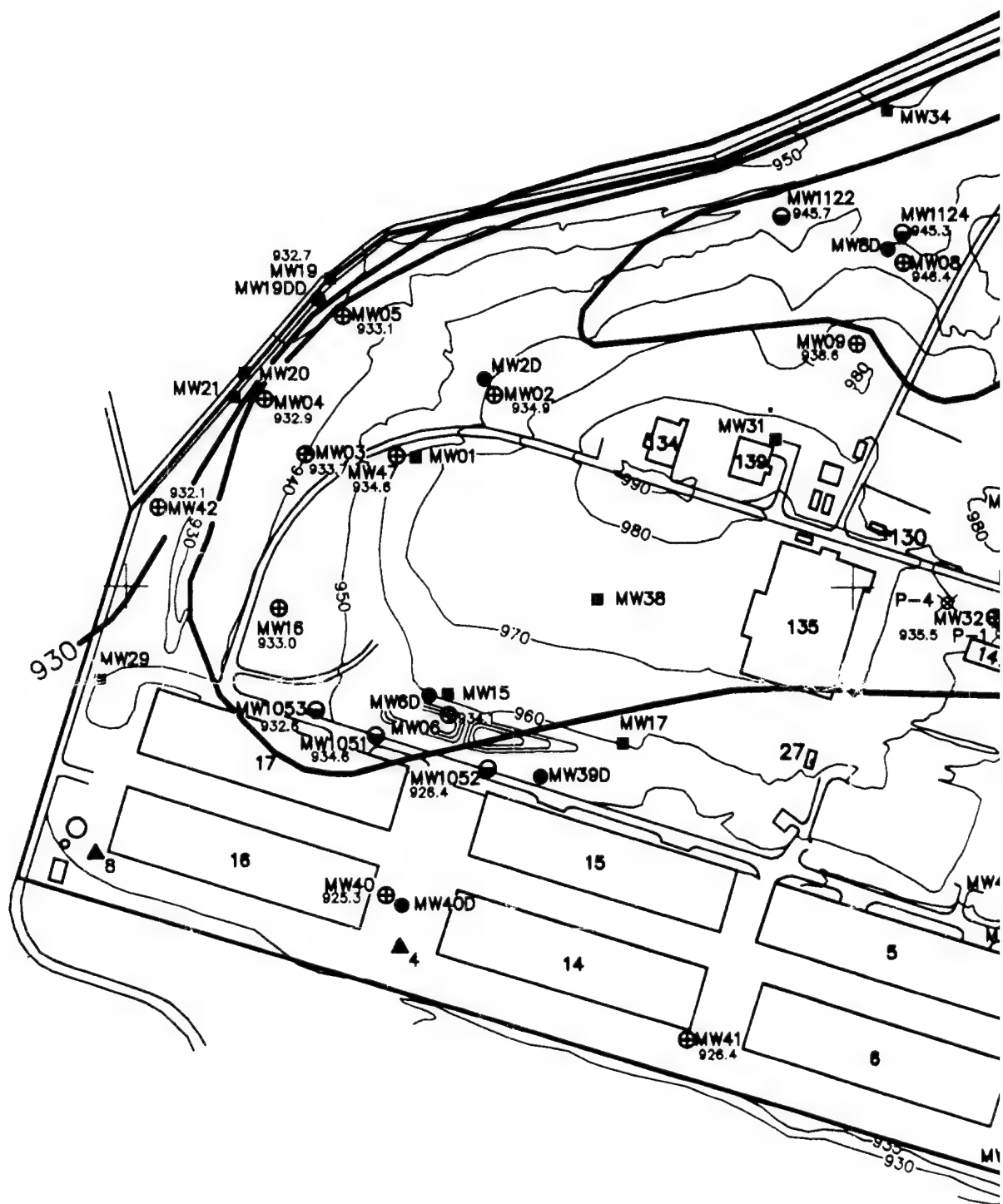
B

13,836,000N

2,406,000E

LEGEND

- DRY HOLES
- EXISTING WELLS
- ⊕ SHALLOW WELLS

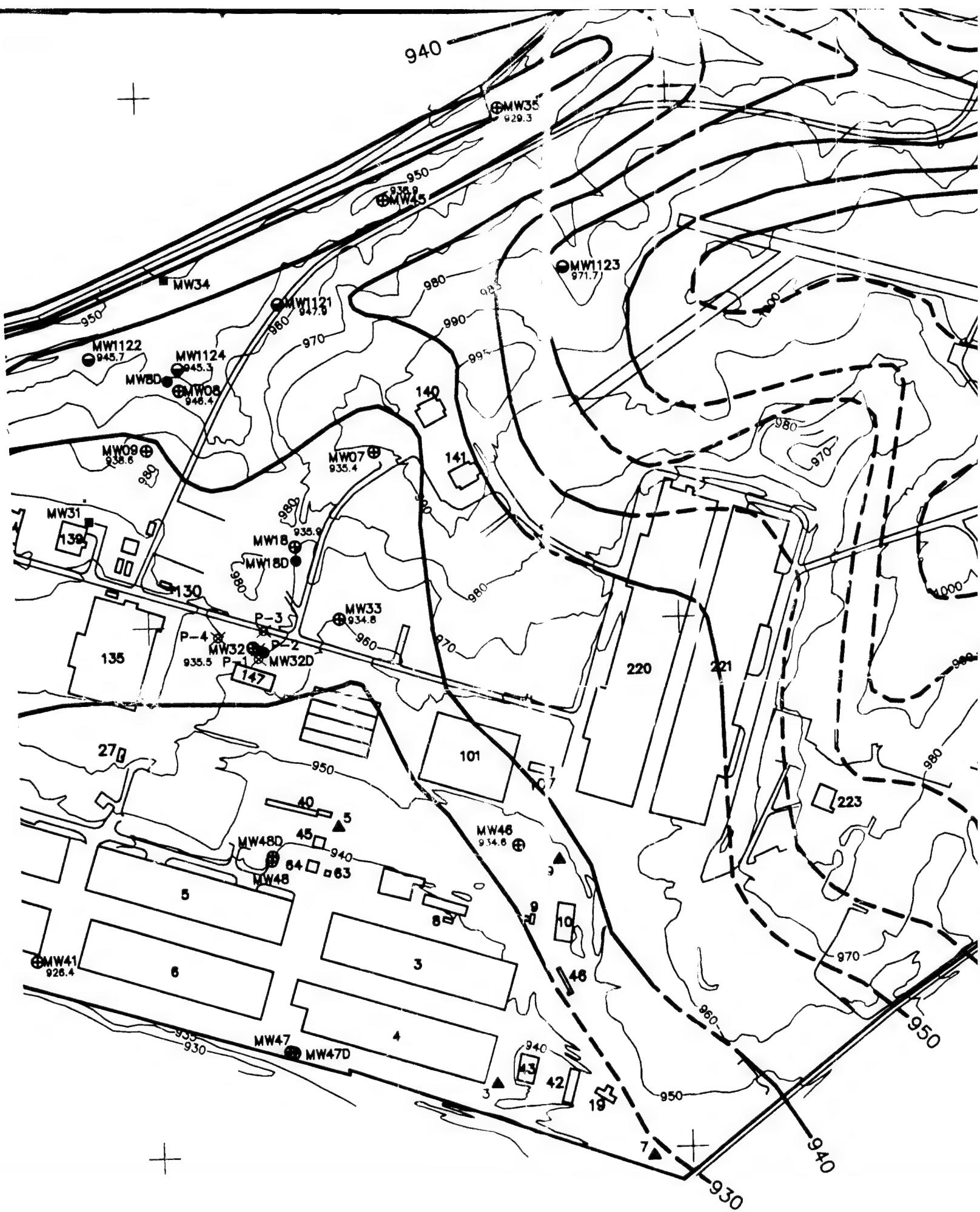


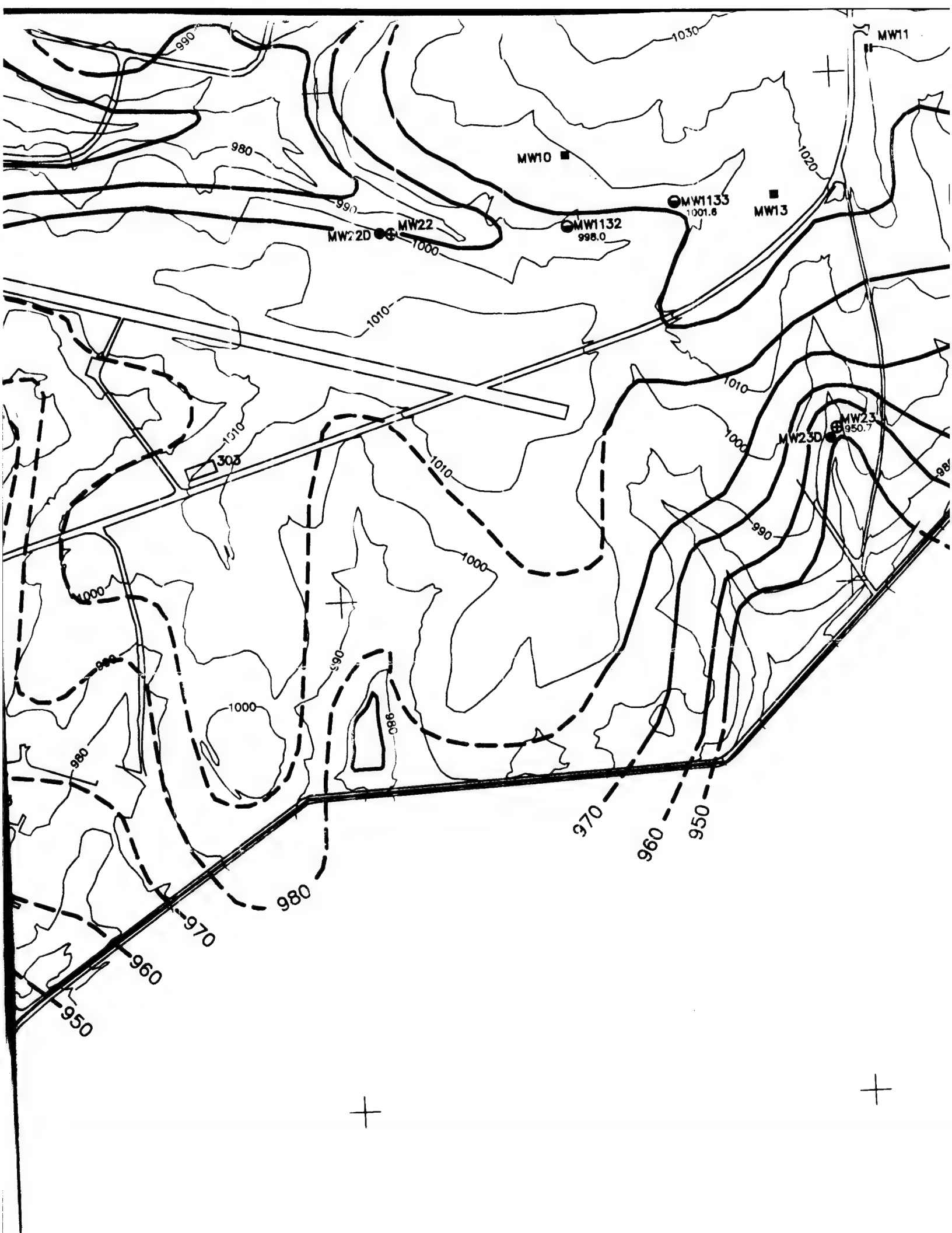
# LEGEND

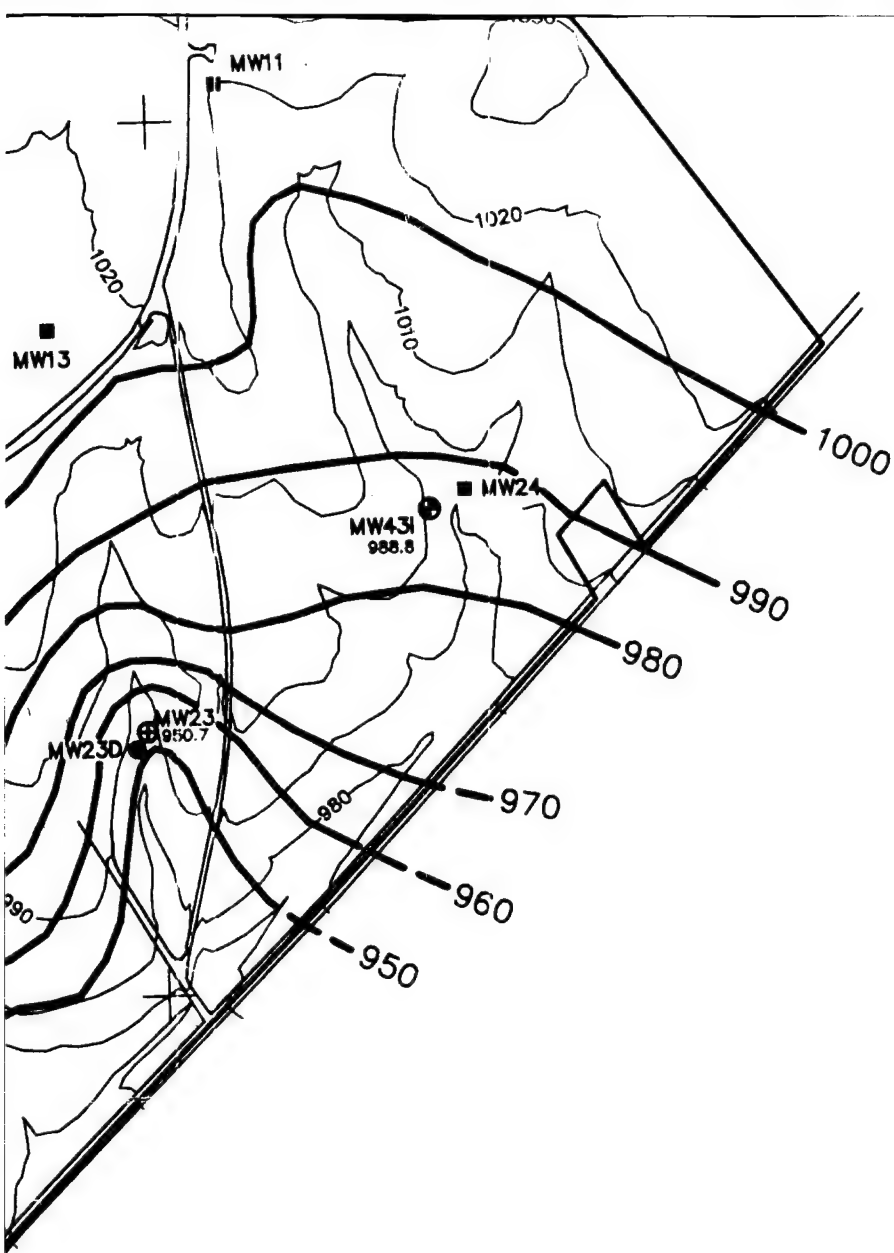
DRY HOLES

EXISTING WELLS

SHALLOW WELLS



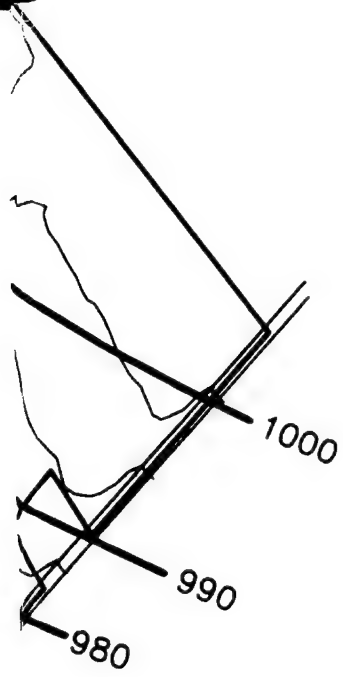




2,418,000E

13,836,000N





2,418,000E

13,836,000N

C

B

B

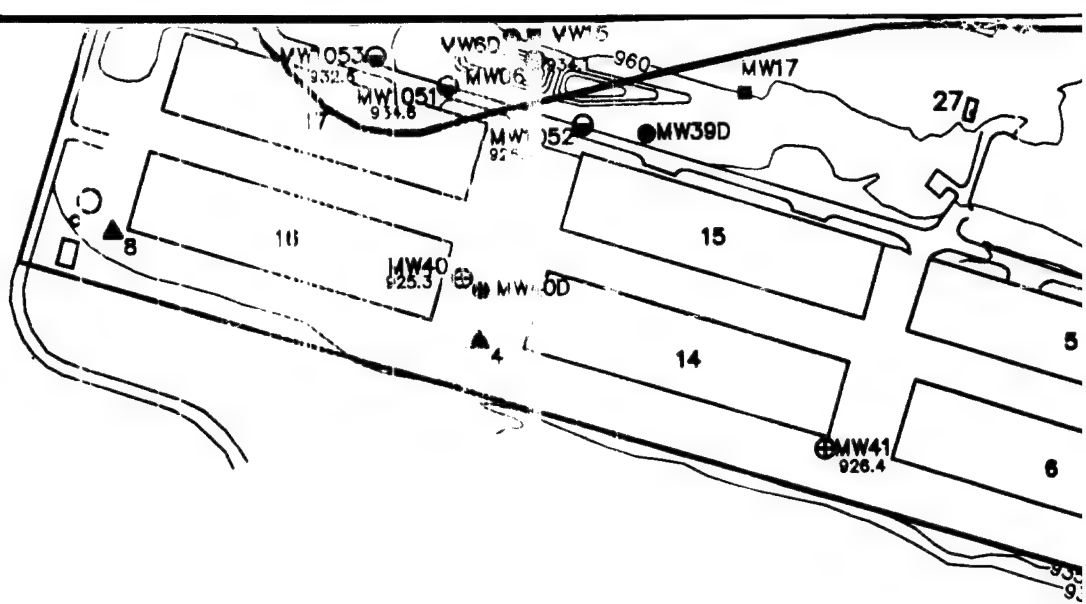
13,836,000N | 2,406,000E

A

### LEGEND

- DRY HOLES
- EXISTING WELLS
- ⊕ SHALLOW WELLS
- DEEP WELLS
- ⊕ BEDROCK INTERFACE WELL
- ▲ PRODUCTION WELL
- ⊗ PIEZOMETER

NUMBER	DATE	MADE BY	CHECKED BY	DESCRIPTION
REVISIONS				

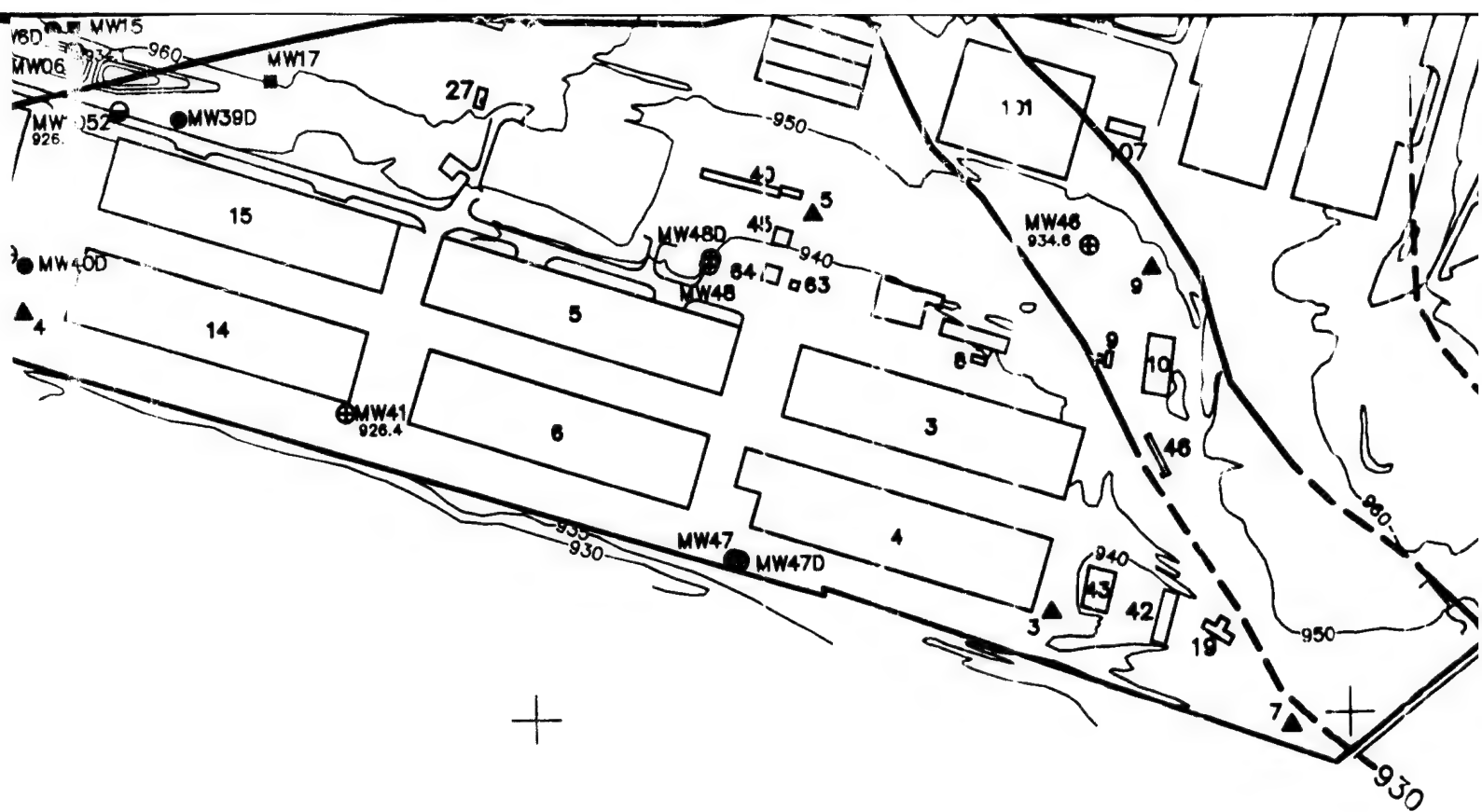


## LEGEND

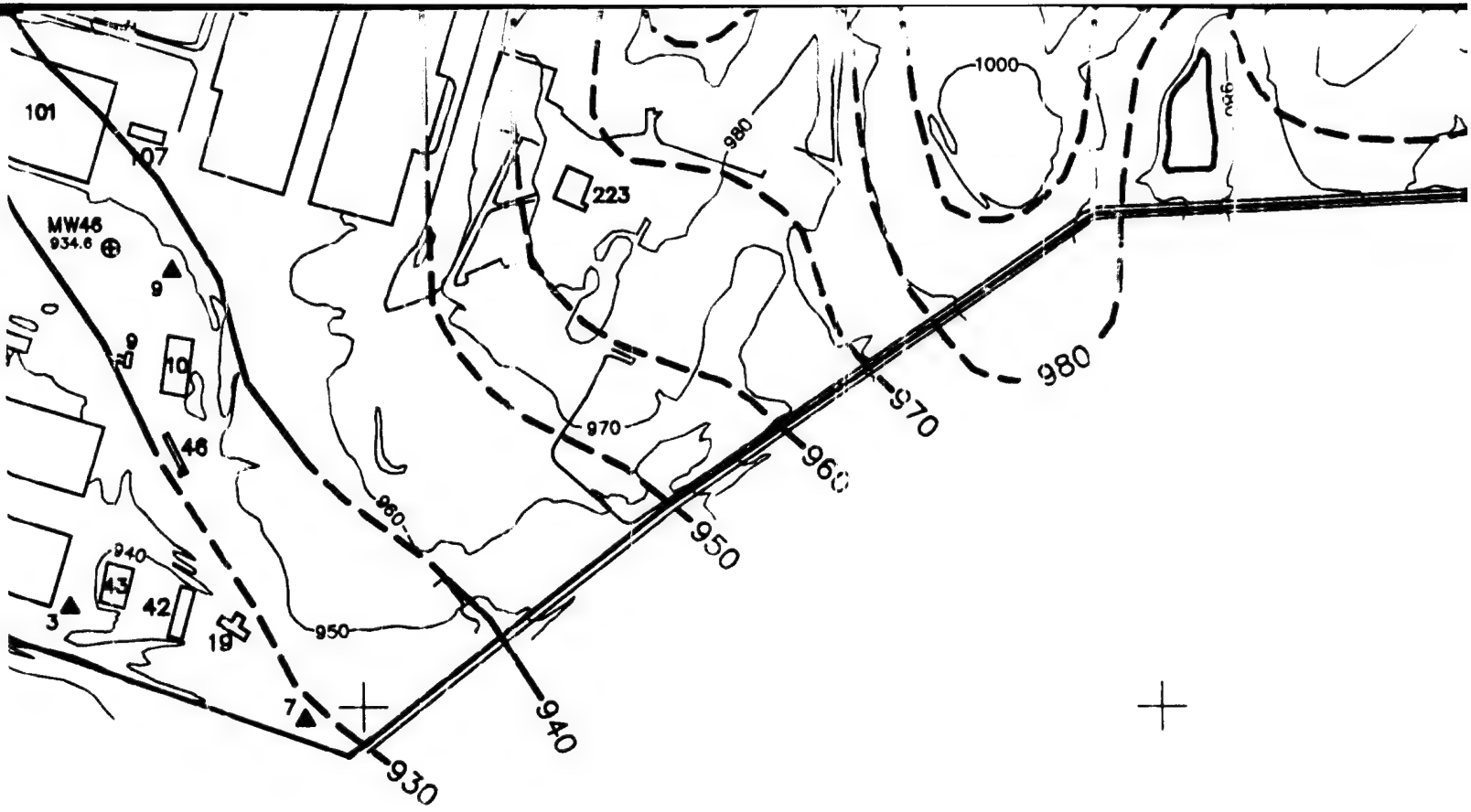
- DRY HOLES
- EXISTING WELLS
- ⊕ SHALLOW WELLS
- DEEP WELLS
- ⊕ BEDROCK INTERFACE WELL
- ▲ PRODUCTION WELL
- ⊗ PIEZOMETER



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		CAP	
		DEPT. CHECK	
		PROJ. CHECK	



DRAWN BY CAP		
DEPT. CHECK		
PROJ. CHECK		
		REG. PROF. ENGR.



**M&E**

**Metcalf & Eddy**

SCALE: 1" = 437.44'

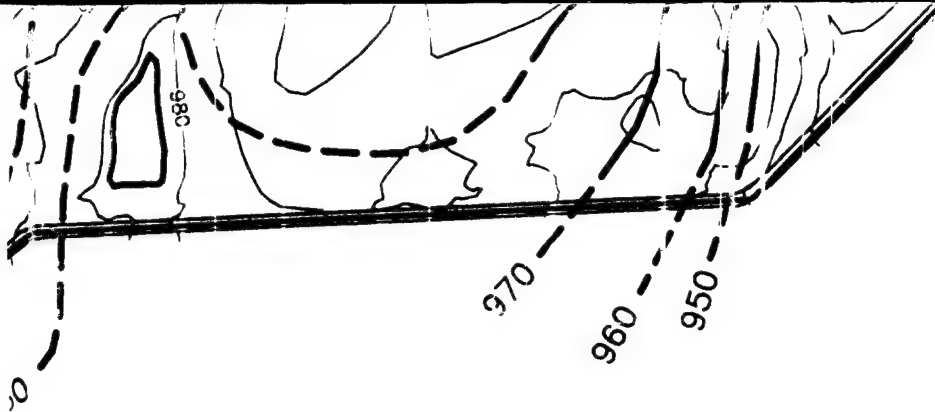
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REG. PROF. ENGR.

DATE

UNLESS OTHERWISE NOTED OR CHANGED



SCALE: 1" = 437.44'



LEXINGTON BLUEGRASS AI  
POTENTIOMETRIC SU  
SHALLOW AQUIF

LEXINGTON, KENTU

UNLESS OTHERWISE NOTED OR CHANGED BY REPRODUCTION

B

2,418,000E

13,836,000N

A

ON BLUEGRASS ARMY DEPOT

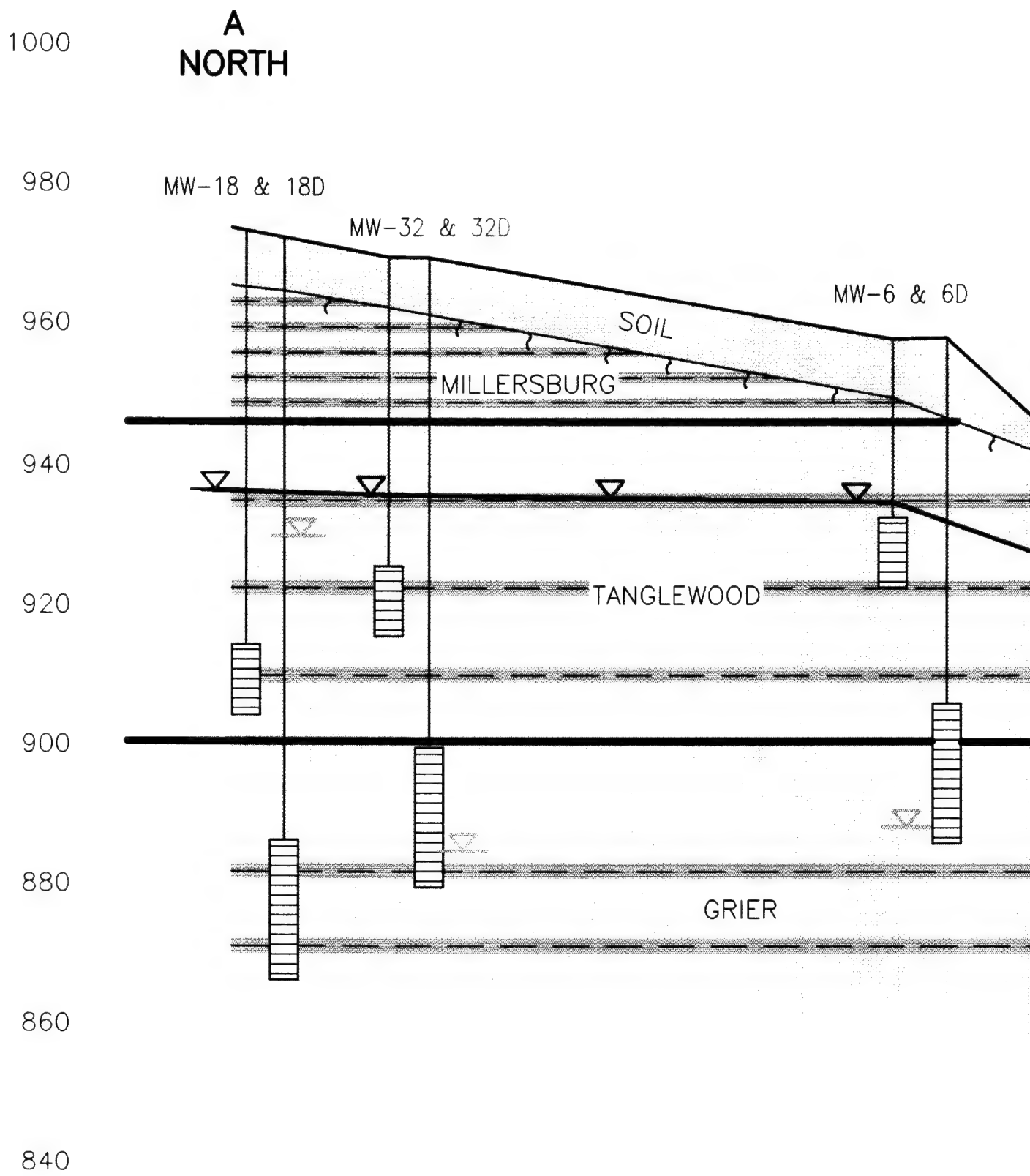
TIOMETRIC SURFACE  
ALLOW AQUIFER

EXINGTON, KENTUCKY

JOB 012308

FILE NO. 308-3-4








FIGURE 3-4

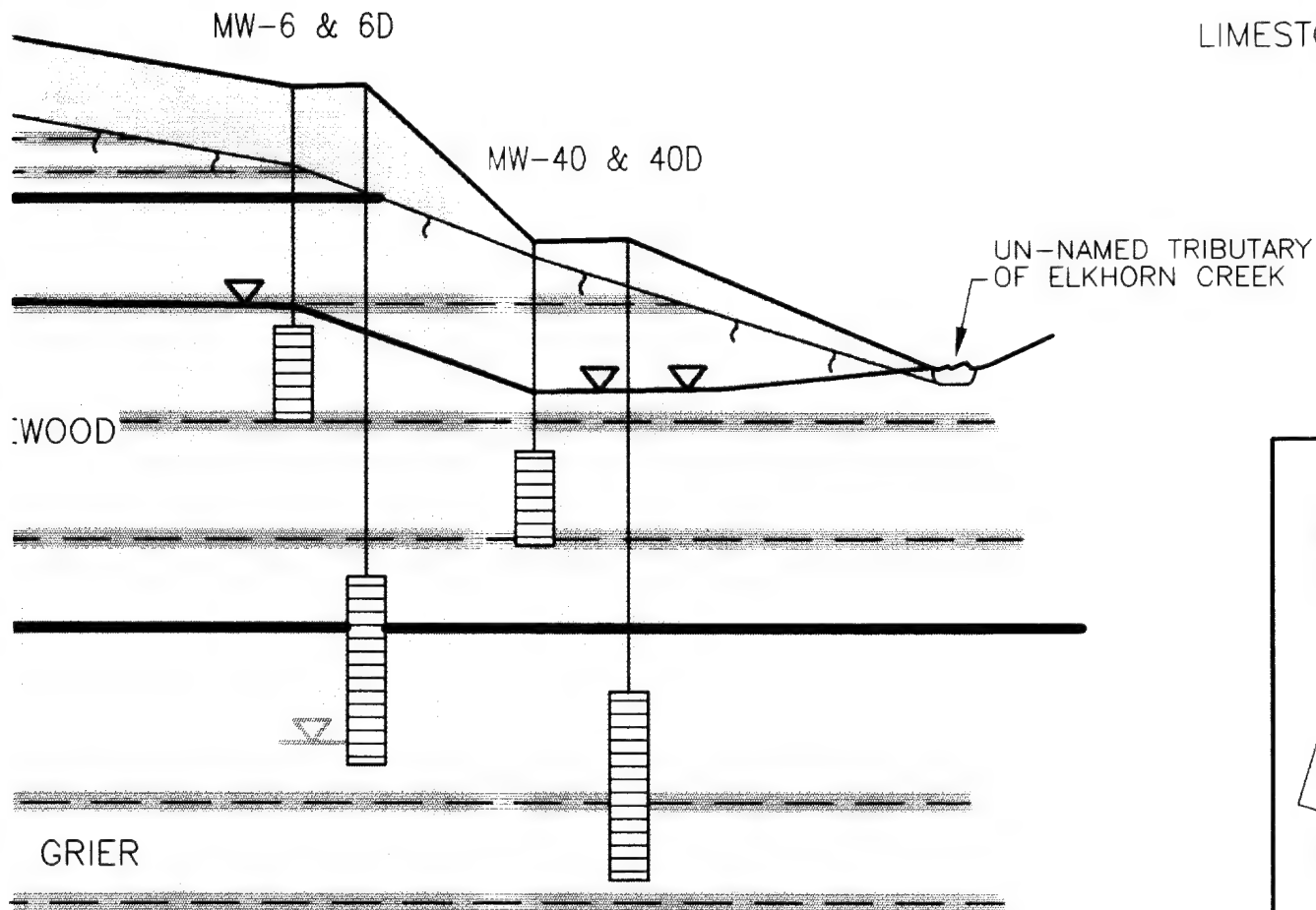




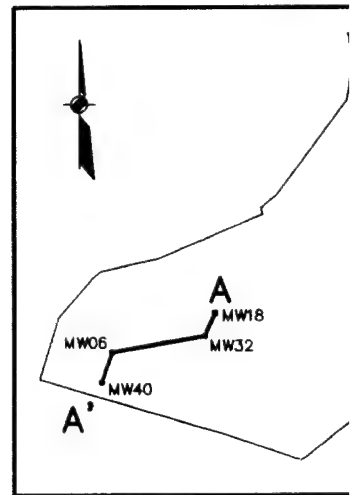
A'  
SOUTH

# LEGEND

-  WELL SCREEN
-  SHALLOW WELLS WATER
-  DEEP WELLS WATER LE
-  SOIL
-  FRACTURED BEDROCK/
-  LITHOLOGIC CONTACT
-  SHALE - 10% OF LITH  
LIMESTONE



SITE



**M&E** Met

LEXINGTON BLUGRAS








GEOLOGIC CROSS

LEXINGTON, KY

VERTICAL SCALE: 1" = 20'  
HORIZONTAL SCALE: 1" = 437.44'

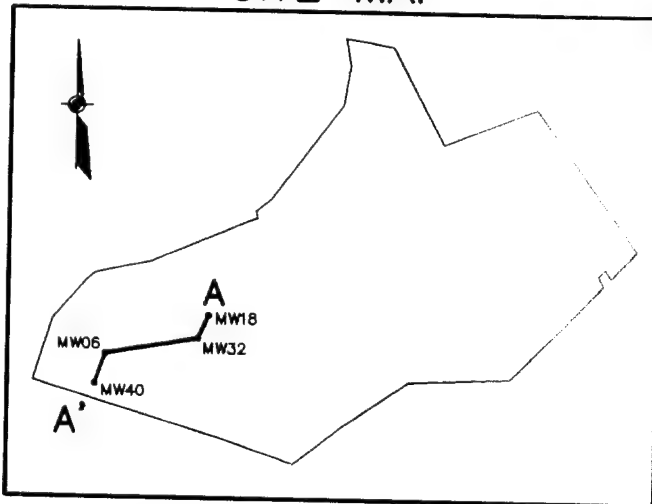
FILE NAME	CHECKED	DRAWN	DATE
MW-A		CAP	SEPT

## LEGEND

-  WELL SCREEN
-  SHALLOW WELLS WATER LEVEL (9/21/92)
-  DEEP WELLS WATER LEVEL (9/21/92)
-  SOIL FRACTURED BEDROCK/SOIL INTERFACE
-  LITHOLOGIC CONTACT
-  SHALE - 10% OF LITHOLOGIC UNITS
-  LIMESTONE

JN-NAMED TRIBUTARY  
OF ELKHORN CREEK

## SITE MAP



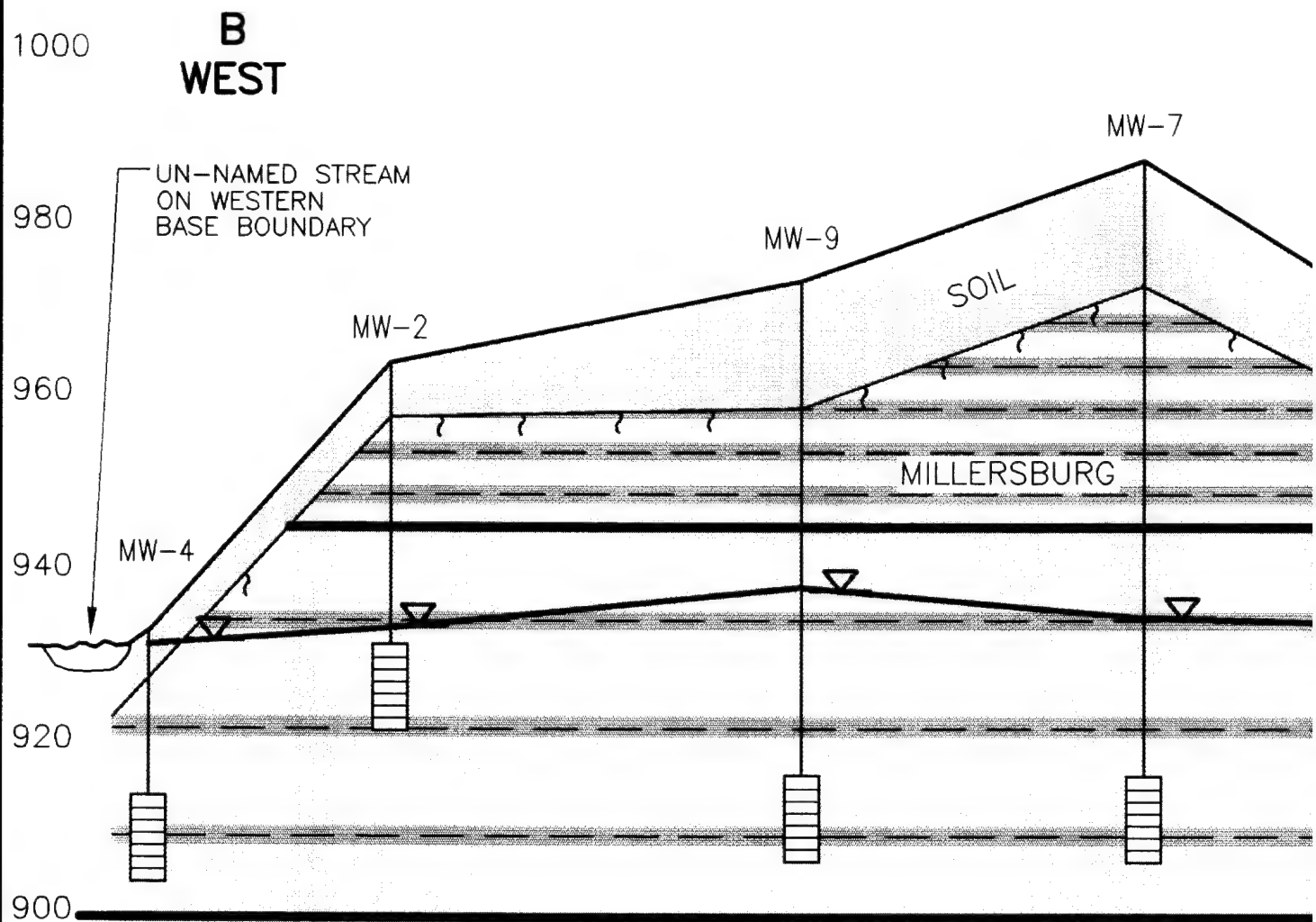
**Metcalf & Eddy**

LEXINGTON BLUGRASS ARMY DEPOT






## GEOLOGIC CROSS SECTION A-A'

LEXINGTON, KENTUCKY

FILE NAME	CHECKED	DRAWN	DATE	PROJECT NO.	FIGURE
MW-A		CAP	SEPT. 95	012308-0006	3-5



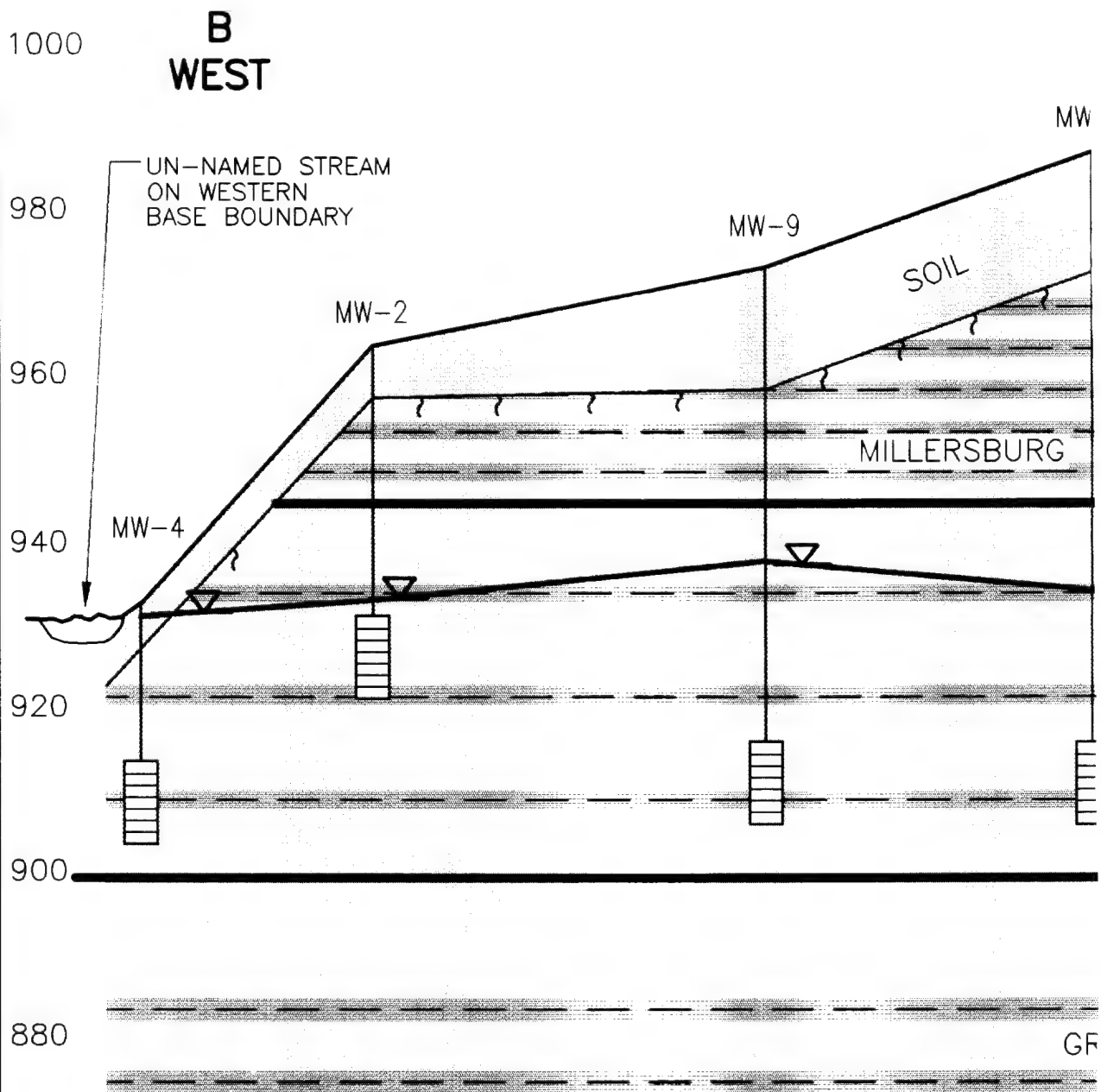
### LEGEND

-  WELL SCREEN
-  SHALLOW WELLS WATER LEVEL (9/21/92)
-  SOIL  
FRACTURED BEDROCK/SOIL INTERFACE
-  LITHOLOGIC CONTACT
-  SHALE - 10% OF LITHOLOGIC UNIT  
LIMESTONE

VERTICAL SCALE: 1" = 20'  
HORIZONTAL SCALE: 1" = 437.44'







### LEGEND



WELL SCREEN



SHALLOW WELLS WATER LEVEL (9/21/92)



FRACTURED BEDROCK/SOIL INTERFACE



LITHOLOGIC CONTACT



SHALE - 10% OF LITHOLOGIC UNIT

LIMESTONE

VERTICAL SCALE: 1" = 20'  
HORIZONTAL SCALE: 1" = .

## **4.0 QUALITY ASSURANCE/QUALITY CONTROL**

This section discusses the documentation, quality control, laboratory analyses, data management, and data evaluation procedures used during the groundwater investigation at LBAD.

### **4.1 QUALITY ASSURANCE PROGRAM**

The Quality Assurance (QA) Program for this investigation incorporated all of the components of the USAEC Installation Restoration QA Program, including requirements for the field sampling program, laboratory analytical procedures, data review, and data management. Section 4.2 provides a summary of the Quality Control (QC) activities required to comply with the QA program; Section 4.3 describes analytical methods used; Section 4.4 contains the data quality assessment; and Section 4.5 describes project data management activities.

### **4.2 QUALITY CONTROL MEASURES OVERVIEW**

To comply with USAEC QA/QC requirements, the sampling and analysis program included collection and analysis of various quality control samples such as equipment rinseate blanks, field blanks, trip blanks, and field sample duplicates. Internal laboratory quality control included analysis of method blanks, laboratory replicates, surrogate standards (for organics), and laboratory control samples (for inorganics) to assess the performance of analytical methods and procedures.

USAEC procedures in the Installation Restoration Data Management Information System (IRDMIS) software were used to validate precision and accuracy of all environmental data generated by this investigation. QC results were evaluated in accordance with specific procedures detailed in the USAEC Installation Restoration Quality Assurance Program, January 1990. M&E also performed a data evaluation of the sample data with respect to blank results, in accordance with the *National Functional Guidelines for Evaluating Organic Data Review*, USEPA, June, 1991 (*Organic Functional Guidelines*) and the *National Functional Guidelines for Evaluating Inorganics Analyses*, July, 1988 (*Inorganic Functional Guidelines*).

Files were submitted directly to Potomac Research Inc. (PRI) by M&E following the required group and record checks. PRI then performed an additional check against map files which were stored in the IRDMIS database. Performance checks were also conducted by IRDMIS using specific validation

criteria. Once the data were determined to be valid, they were uploaded into the IRDMIS pyramid. This represents usable, Level 3 data that are accessible to authorized M&E personnel via modem for review, evaluation, and downloading into specific formats.

### **4.3 ANALYTICAL SERVICES**

Metcalf & Eddy, Inc. (M&E) contracted with DataChem, Inc., located in Salt Lake City, Utah, to perform the analyses all groundwater samples collected at LBAD.

#### **4.3.1 Analytical Methods**

Samples collected during the groundwater investigation were analyzed for the U.S. EPA Target Compound List (TCL) volatile and semivolatile organics, pesticides, and polychlorinated biphenyls (PCBs) and the Target Analyte List (TAL) inorganic constituents. TCL volatile and semivolatile organic compounds were analyzed by Gas Chromatography/Mass Spectrometry (GC/MS). TCL pesticides and PCBs were analyzed by Gas Chromatography (GC). TAL metals were analyzed by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP) and Atomic Absorption Spectroscopy (AA). Arsenic, selenium, and lead were analyzed by Graphite Furnace AA, and mercury by Cold-Vapor AA. Cyanide was analyzed by a colorimetric method. Table 4.1 lists the USAEC-certified methods and corresponding USEPA methods used for sample analyses during this investigation.

#### Method Certification

Prior to sampling and analysis of the groundwater samples, the laboratory was required to obtain USAEC certification for each analytical method used. Requirements for certification are detailed in the USAEC Installation Restoration Quality Assurance Program, January 1990. Certification for each method used was accomplished by analyzing a standard mixture of target analytes and surrogate compounds (organics). The resulting data were subjected to statistical analysis using USAEC-supplied computer software.

#### Reporting Limits

Certified Reporting Limits (CRLs) used during this investigation were specific to DataChem and represent the lowest sample concentration that may be reliably reported for each analyte using the USAEC certified

method. Tables 4.2 through 4.6 list the individual analytes analyzed by analyte class, the IRDMIS code names, and their corresponding CRLs.

### Unknown Compounds

In addition to those target organic compounds analyzed for the groundwater investigation, additional organic compounds were tentatively identified and designated as Unknowns or Tentatively Identified Compounds (TICs). These compounds were all those represented by peaks with an area of 10 percent or more of the area of the nearest-eluting internal standard or which showed an estimated concentration in excess of approximately 10 µg/l.

For volatile organic compounds, xxx represents a value that is 100 times the relative retention time. For semivolatiles xxx represents 100 times the relative retention time plus 500. TICs reported as UNKxxx are those that cannot be identified with greater than 95 percent certainty.

#### **4.3.2 Analytical Lot Information**

The laboratory has assigned each compound analyzed for each sample to a specific lot, each of which includes the necessary laboratory QC samples. A lot designation consists of three letters such as ROC, RND, etc. A total of 14 lots were associated with the groundwater samples. Lot-specific method blanks were used by M&E during data evaluation (see below).

### **4.4 DATA QUALITY ASSESSMENT**

Quality control measures and procedures as outlined in the Sampling and Analysis plan (Jacobs Engineering, 1989) were followed. Data quality characteristics that were evaluated are accuracy, precision, and completeness.

#### **4.4.1 Accuracy**

Accuracy measures bias within a measurement system. Sources of error are the sampling process, field contamination, sample handling, interference with analyte measurement due to sample matrix, sample preparation, and analytical techniques. Accuracy for the LBAD groundwater investigation was assessed



through the use of surrogates, method blanks, field blanks, equipment rinseate blanks, trip blanks, and field duplicates.

#### 4.4.1.1 Blank Contamination

M&E reviewed the laboratory method blank results, equipment rinseate blank results, field blank results and trip blank results, and qualified field sample data in accordance with the *Inorganic Functional Guidelines* and the *Organic Functional Guidelines*. No contaminants should be present in any blanks associated with the field samples. If blank contamination exists, the field sample results are reviewed and USEPA data qualifiers placed on the results if necessary. The action to be taken if blank contamination is present is that any inorganic sample result greater than the reporting limit and less than five times the blank concentration should be qualified as non-detected (U) at an elevated quantitation limit equal to the concentration reported by the laboratory. Positive organic sample results for common laboratory contaminants such as acetone or methylene chloride that are less than ten times the blank concentration are qualified as non-detected (U) at an elevated quantitation limit equal to the concentration reported by the laboratory. For other organic compounds, positive sample results are qualified as non-detect at an elevated quantitation limit equal to the reported concentration, if that concentration is less than five times its level in the associated blank.

#### Method Blanks - Organics

One volatile organic compound, trichloroethene, and four pesticides, alpha-benzenehexachloride, DDT, isodrin, and heptachlor were detected in seven of the fourteen method blanks analyzed with the groundwater samples.

Trichloroethene, alpha-benzene hexachloride, DDT, and heptachlor were not detected in any of the field samples associated with these method blanks. Therefore, no data for these parameters were qualified.

Contamination in method blanks can originate from various sources which include carry-over, cross-contamination, and inadequate performance of the laboratory's water-purification system.

### Method Blanks - Inorganics

Three inorganic constituents, aluminum, sodium, and zinc, were detected in four of the fourteen method blanks analyzed with the groundwater samples.

Only one of these inorganic constituents, zinc, was detected in thirty-five of the groundwater samples at concentrations ranging from 19.1  $\mu\text{g/l}$  to 1900  $\mu\text{g/l}$ . Zinc concentrations in the associated method blanks were 18.5  $\mu\text{g/l}$ , 27.5  $\mu\text{g/l}$ , and 44.3  $\mu\text{g/l}$ . After evaluation, only one sample, S004MW0400, required qualification of the zinc result as a non-detect at an elevated quantitation limit of 35.1  $\mu\text{g/l}$ . Table 4.7 outlines the results.

### Trip Blanks

Acetone, chloroform, o,p-xylenes, and 1,3-dimethylbenzene were detected in trip blanks associated with the field samples. Acetone was detected in two trip blanks at concentrations of 61.7  $\mu\text{g/l}$  and 76.5  $\mu\text{g/l}$ ; chloroform was detected in sixteen trip blanks at concentrations ranging from 1.0  $\mu\text{g/l}$  to 6.7  $\mu\text{g/l}$ ; xylene was present in one trip blank at 2.2  $\mu\text{g/l}$ ; and 1,3-dimethyl benzene was present in two trip blanks at concentrations ranging from 1.11  $\mu\text{g/l}$  to 2.3  $\mu\text{g/l}$ . Table 4.8 presents the trip blank results.

Acetone, chloroform, 1,3-dimethylbenzene, and o,p-xylenes were not present in any of the associated field samples.

Acetone and 1,3-dimethylbenzene present in some field samples not associated with trip blanks of concern at concentrations of  $> 100 \mu\text{g/l}$  and 1.4 to 16  $\mu\text{g/l}$ , respectively. It could be considered that these two constituents are site-derived contamination. The chloroform and the o,p-xylenes may be artifacts of laboratory contamination.

Trip blanks originate from the laboratory; therefore, the presence of chloroform and the o,p-xylenes in the trip blanks may be a result of inadequate performance of the laboratory's water-purification system.

### Field Blanks

Field blanks associated with the groundwater samples contained no inorganic or organic contaminants.

#### Equipment Rinseate Blanks

Equipment rinseate blanks associated with the groundwater samples contained no inorganic or organic contaminants.

#### **4.4.1.2**      MS/MSD Samples

No samples were selected in the field for designation as matrix spike and matrix spike duplicate samples. However, as an internal QC procedure, the laboratory performed matrix spike and matrix spike duplicate analyses. The percent difference between the values of the spiked duplicate was used as an indicator of precision, while the percent recovery of the spiked analyte was used as an indicator of accuracy. The MS/MSD results for this investigation were considered acceptable.

#### **4.4.2 Precision**

Precision measures the reproducibility of measurements under a given set of conditions. It is a quantitative measure of the variability of a group of measurements. Precision of the data generated during the groundwater investigation was evaluated through the assessment of matrix spike/matrix spike duplicate analyses.

#### **4.4.3 Completeness**

Following the review of the analytical data a percent completeness was calculated by dividing the number of acceptable results by the total number of analytical results requested. A percent completeness of 100 percent was achieved for the LBAD groundwater investigation.

### **4.5 DATA MANAGEMENT**

IRDMIS is the ultimate repository for all data collected under the LBAD groundwater investigation in support of the Installation Restoration (IR) activities of USAEC. IRDMIS is a relational database that supports all aspects of storage, retrieval, validation, and reporting of analytical and field data. This system is run and maintained by a USAEC subcontractor, Potomac Research, Incorporated (PRI) located in Aberdeen Proving Ground, Maryland.

The field data were entered into various files by M&E, and submitted to PRI. The analytical data were entered into chemical files by DataChem, and submitted to M&E for review. After being reviewed, these chemical files were then forwarded to PRI. The microcomputer software which was used to create and manipulate these files was PCTOOL, version 4.3.

#### Geologic and Hydrogeologic Data

Data from well construction diagrams were transferred to Geotechnical Data Entry Coding Forms using conventions found in the IRDMIS Data Dictionary. This information was placed in two IRDMIS files:

**Well Construction** - Includes data collected on well construction such as well depth, screen depth, backfill material, etc.

**Groundwater Stabilized** - Includes data on water levels measured over the course of the groundwater investigation from monitoring wells.

These geotechnical data were then entered into PCTOOL and transferred to the IRDMIS database. The geotechnical data which were collected and submitted are accessible from the IRDMIS database.

#### **4.5.1 Chemical Data**

The analytical data were evaluated by the USAEC chemistry branch and then by M&E. Field samples were designated by a specific coding system that was used to track the samples. Control charts were submitted by the laboratory to evaluate precision and accuracy of the methods used for each parameter, and flagging codes and/or data qualifiers were placed on the data to indicate unusual analytical conditions.

#### Sample Designation

A sample coding system consistent with the requirements of IRDMIS was applied to all environmental samples collected during the groundwater investigation. Sample designations include a location ID, type of sample, and depth of collection, if applicable. A four digit field number was also applied to each sample collected. The field numbers associated with the field samples were applied in consecutive order.

Field quality control samples such as trip blanks, field blanks, and equipment rinseate blanks have the same designations in the site ID except the type of sample is replaced with "TB" for trip blanks, "ER" for equipment rinseate blanks, "FB" for field blanks, "FD" for field duplicate, and "RE" for resample. Each was numbered consecutively as it was obtained and corresponds to a particular SWMU.

#### Control Chart Submittal

Under the USAEC QA program the laboratory was required to apply precision and accuracy criteria to each parameter that was analyzed through the use of the IRDMIS software. This required review and evaluation of analytical data and generation of daily control charts used to track and monitor the performance of each method for each analyte reported. Data used in control charts were derived from certification data and daily quality control samples. All control charts generated by the laboratory were submitted directly to the USAEC Project Chemist at the Technical Support Division for review. A determination of acceptance of analytical data was made for each data lot. These determinations are based on evidence of control of analytical systems and meeting of all quality control criteria as defined by the program. After the analytical data are reviewed and approved they are then elevated to Level 3 data, where they are accessible through the IRDMIS pyramid.

#### Flagging Codes

Part of the IRDMIS data validation process requires the use of flagging codes which are applied to the analytical results to indicate unusual analytical conditions. These flagging codes are placed on the analytical data as part of the review process by the USAEC Chemistry Branch. The flagging codes used in reporting the LBAD groundwater data are defined as follows:

#### Flagging Codes

- C: Analysis was confirmed.
- D: Duplicate sample or test name.
- H: Out of control but data accepted due to high recoveries.
- R: Analyte required for reporting purposes but not currently certified.
- S: Results based on internal standard.
- U: Analysis is unconfirmed.
- 1: Results less than the CRL but greater than the COD.

#### **4.5.2 Map Location Data**

Map files were completed first to establish locations for the chemical and geotechnical data. After wells were installed, locations were surveyed and elevations calculated. These data along with other pertinent information were then transferred to Map Coding Forms, entered into the microcomputer software, PCTOOL, and transferred to the IRDMIS database. The coordinates for all samples which were collected at the facility are accessible from the IRDMIS database.

#### **4.5.3 Quality Control**

A key function of the data management program established by USAEC is collection, management, and processing of QC information, and the automated elevation of investigative data in accordance with the USAEC QA program guidelines for QC samples. Such field, trip and equipment rinse blanks and field duplicated were entered into IRDMIS along with chemical data for investigative samples.

**Table 4.1**  
**USAEC CERTIFIED METHODS AND**  
**U.S. EPA METHODS**

Analysis	WATER	
	USAEC Certified Method	Equivalent U.S. EPA Method
Total Petroleum Hydrocarbons	00	418.1 (a)
Volatile Organic Compounds	UM21	624 (b)
Semivolatile Organic Compounds (Acid + Base/Neutral Extractable)	UM25	625 (b)
Organochlorine Pesticides & Polychlorinated Biphenyls	UH20	608 (b)
Chlorinated Herbicides	UH10	615 (b)
Metals (ICP)	SS12	6010 (c)
Mercury	CC8	245.1 (a)
Arsenic	AX8	206.2 (a)
Lead	SD18	239.2 (a)
Selenium	SD25	270.2 (a)
Silver	SD26	6010 (c)
Cyanide	TF34	9012 (c)

- (a) *Methods for Chemical Analysis of Water and Wastes*, EPA 600/4-79-020, March 1983.  
 (b) Federal Register, Vol. 49, No. 209, October 26, 1984.  
 (c) *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition, Rev. 1, December 1987.

**Table 4.2**  
**USAEC SPECIFIC CERTIFIED REPORTING LIMITS**  
**TCL - VOLATILE ORGANIC COMPOUNDS**

		USAEC CRL
IRDMIS CODE NAME	CHEMICAL NAME	WATER (µg/l)
111TCE	1,1,1-Trichloroethane	1.0
112TCE	1,1,2-Trichloroethane	1.5
11DCE	1,1-Dichloroethylene	1.0
11DCLE	1,1-Dichloroethane	1.0
12DCLE	1,2-Dichloroethane	1.0
12DCLP	1,2-Dichloropropane	1.0
13DMB	1,3-Dimethylbenzene (m-Xylene)	1.0
2C70	2-Hexanone	0.75
ACET	Acetone	8.0
BRDCLM	Bromodichloromethane	1.0
C12DCE*	cis-1,2-Dichloroethylene	5.0
C13DCP	cis-1,3-Dichloropropylene	4.8
C2H3CL	Vinyl Chloride	12.0
C2H5CL	Chloroethane	8.0
C6H6	Benzene	1.0
CCL4	Carbon tetrachloride	1.0
CH2CL2	Methylene Chloride	1.0
CH3BR	Bromomethane	14.0
CH3CL	Chloromethane	1.2
CHBR3	Bromoform	11.0
CHCL3	Chloroform	1.0
CLC6H5	Chlorobenzene	1.0
CSZ	Carbon Disulfide	0.95
DBRCLM	Dibromochloromethane	1.0
ETC6H5	Ethylbenzene	1.0
MEC6H5	Toluene	1.0
MEK	Methylethyl Ketone	10.0
MIBK	Methylisobutyl Ketone	1.4
STYR	Styrene	0.43
T12DCE	trans-1,2-Dichloroethylene	5.0
T13DCP	trans-1,3-Dichloropropene	4.8
TCLEA	1,1,2,2-Tetrachloroethane	1.5
TCLEE	Tetrachloroethylene	1.0
TRCLE	Trichloroethylene	1.0
XYLEN	o,p-Xylenes	1.0

\* listed as 12DCE in soils (1,2-Dichloroethylene)



**Table 4.3**  
**USAEC SPECIFIC CERTIFIED REPORTING LIMITS**  
**TCL - SEMIVOLATILE ORGANIC COMPOUNDS**

		USAEC CRL
IRDMIS CODE NAME	CHEMICAL NAME	WATER (µg/l)
124TCB	1,2,4-Trichlorobenzene	2.4
12DCLB	1,2-Dichlorobenzene	1.2
13DCLB	1,3-Dichlorobenzene	3.4
14DCLB	1,4-Dichlorobenzene	1.5
245TCP	2,4,5-Trichlorophenol	2.8
246TCP	2,4,6-Trichlorophenol	3.6
24DCLP	2,4-Dichlorophenol	8.4
24DMPN	2,4-Dimethylphenol	4.4
24DNP	2,4-Dinitrophenol	176.0
24DNT	2,4-Dinitrotoluene	5.8
26DNT	2,6-Dinitrotoluene	6.7
2CLP	2-Chlorophenol	2.8
2CNAP	2-Chloronaphthalene	2.6
2MNAP	2-Methylnaphthalene	1.3
2MP	2-Methylphenol	3.6
2NANIL	2-Nitroaniline	15.0
2NP	2-Nitrophenol	96.0
33DCBC	3,3-Dichlorobenzidine	5.0
3NANIL	3-Nitroaniline	15.0
46DN2C	2-Methyl-4,6-dinitrophenol	50.0
4BRPPE	4-Bromophenylphenylether	22.0
4CANIL	4-Chloroaniline	13.2
4CL3C	3-Methyl-4-chlorophenol	8.5
4CLPPE	4-Chlorophenylphenylether	23.0
4MP	4-Methylphenol	2.8
4NANIL	4-Nitroaniline	21.4
4NP	4-Nitrophenol	96.0
ANAPNE	Acenaphthene	5.8
ANAPYL	Acenaphthylene	5.1
ANTRC	Anthracene	5.2
B2CLEE	bis(2-chloroethyl)ether	0.68
B2CEXM	bis(2-chloroethoxy)methane	6.8
B2EHP	bis(2-ethylhexyl)phthalate	7.7
BAANTR	Benzo[A]anthracene	9.8
BAPYR	Benzo[A]pyrene	14.0
Continued...		

**Table 4.3 (Cont'd)**  
**USAEC SPECIFIC CERTIFIED REPORTING LIMITS**  
**TCL - SEMIVOLATILE ORGANIC COMPOUNDS**

IRDMIS CODE NAME	CHEMICAL NAME	USAEC CRL
		WATER (µg/l)
BBFANT	Benzo[B]fluoranthene	10.0
BBZP	Butylbenzyl phthalate	10.0
BGHPY	Benzo[G,H,I]perylene	10.0
BKFANT	Benzo[K]fluoranthene	28.0
BZCIPE	2,2'-oxybis(1-chloropropane)	5.0
CARBAZ	Carbazole	5.0
CHRY	Chrysene	10.0
CL6BZ	Hexachlorobenzene	4.0
CL6CP	Hexachlorocyclopentadiene	7.4
CL6ET	Hexachloroethane	12.0
DBAHA	Dibenz[A,H]anthracene	54.0
DBZFUR	Dibenzofuran	8.3
DEP	Diethylphthalate	12.0
DMP	Dimethyl phthalate	5.1
DNBP	Di-n-butyl phthalate	5.0
DNOP	Di-n-octyl phthalate	2.2
FANT	Fluoranthene	33.0
FLRENE	Fluorene	1.5
HCBD	Hexachlorobutadiene	24.0
ICDPYR	Indeno[1,2,3-C,D]pyrene	9.2
ISOPHR	Isophorone	8.7
NAP	Naphthalene	21.0
NB	Nitrobenzene	2.4
NNDNPA	N-Nitrosodi-N-propylamine	0.5
NNDPA	N-Nitrosodiphenylamine	3.7
PCP	Pentachlorophenol	9.1
PHANTR	Phenanthrene	9.9
PHENOL	Phenol	2.2
PYR	Pyrene	17.0

**Table 4.4**  
**USAEC SPECIFIC CERTIFIED REPORTING LIMITS**  
**TAL - INORGANIC COMPOUNDS AND TPH**

		USAEC CRL
IRDMIS CODE NAME	CHEMICAL NAME	WATER (µg/l)
AS	Arsenic	2.35
AL	Aluminum	112.0
BA	Barium	2.82
BE	Beryllium	1.12
CA	Calcium	105.0
CD	Cadmium	6.78
CO	Cobalt	25.0
CR	Chromium	16.8
CU	Copper	18.8
FE	Iron	77.5
K	Potassium	1240.0
MG	Magnesium	135.0
MN	Manganese	9.67
NA	Sodium	279.0
NI	Nickel	32.1
PB	Lead	0.467
SB	Antimony	60.0
SE	Selenium	2.530
TL	Thallium	125.0
V	Vanadium	27.6
ZN	Zinc	18.0
HG	Mercury	0.1
CYN	Cyanide	5.0
TPHC	Total Petroleum Hydrocarbons	1000.000

**Table 4.5**  
**USAEC SPECIFIC CERTIFIED REPORTING LIMITS**  
**PESTICIDES, HERBICIDES AND PCBs**

		USAEC CRL
IRDMIS CODE NAME	CHEMICAL NAME	WATER (µg/l)
ABHC	alpha-Benzenhexachloride	0.0025
BBHC	beta-Benzenhexachloride	0.0099
DBHC	delta-Benzenhexachloride	0.0034
ACLDAN	alpha-Chlordane	0.0312
AENSLF	Endosulfan I	0.0025
ALDRN	Aldrin	0.0074
BBHC	beta-Benzenhexachloride	0.0099
BENSLF	Endosulfan II	0.077
DBHC	delta-Benzenhexachloride	0.0034
DLDRN	Dieldrin	0.0074
ENDRN	Endrin	0.0176
ENDRNA	Endrin aldehyde	5.0
ESFSO4	Endosulfan sulfate	50.00
GCLDAN	gamma-Chlordane	0.0312
HPCL	Heptachlor	0.0025
HPCLE	Heptachlor epoxide	0.0063
LIN	Lindane	0.0025
MEXCLR	Methoxychlor	0.0750
PPDDD	2-2-Bis(p-chlorophenyl)-1,1-dichloroethane	0.0081
PPDDE	2-2-Bis(p-chlorophenyl)-1,1-dichloroethene	0.0039
PPDDT	2-2-Bis(p-chlorophenyl)-1,1,1-chloroethane	0.6025
TXPHEN	Toxaphene	0.6900
245T	2,4,5-Trichlorophenoxyacetic acid	0.160
24D	2,4-Dichlorophenoxyacetic acid	1.263
SILVEX	Silvex	0.095

**Table 4.6**  
**USAEC SPECIFIC CERTIFIED REPORTING LIMITS**  
**PESTICIDES, HERBICIDES AND PCBs**

		USAEC CRL
IRDMIS CODE NAME	CHEMICAL NAME	WATER (µg/l)
PCB 016	Aroclor 1060	0.3850
PCB 221	Aroclor 1221	0.3850
PCB 232	Aroclor 1232	0.3850
PCB 242	Aroclor 1242	0.3850
PCB 248	Aroclor 1248	0.1760
PCB 254	Aroclor 1254	0.1760
PCB 260	Aroclor 1260	0.1760

**TABLE 4.7**  
**LEXINGTON GROUNDWATER CONCENTRATIONS**

	2-SEPT-92	19-AUG-92	19-AUG-92	10-DEC-91	10-DEC-91	9-DEC-91	2-SEPT-92	24-NOV-91
PARAMETER	AOCMW1009	S001MW2300	S001MW23D0	S003MW1600	S003MW0300	S004FD0500	S004MW0400	S003MW1051
Zinc	66.7 (U)						35.1 (U)	
1,3-Dimethylbenzene		1.4 (U)	4.3 (U)					
Xylene			4.4 (U)					
Isodrin				0.007 U (U)	0.004 U (U)	0.008 U (U)		0.004 U (U)

	24-NOV-91	19-AUG-92	19-AUG-92	11-DEC-91	17-DEC-91	19-AUG-92	19-AUG-92	19-AUG-92
PARAMETER	S003MW1053	S2567FD18D	S2567FD330	S2567MW124	S2567MW180	S2567MW18D	S2567MW330	S004FD4200
1,3-Dimethylbenzene		13 (U)	6.6 (U)			16 (U)	4.0 (U)	1.11 (U)
Xylene			6.3 (U)				4.2 (U)	
Isodrin				0.019 U (U)	0.01 U (U)			
DDT		0.007 U (U)						
NOTE:								

U - This indicates that the results are unconfirmed.

(U) - This indicates that the results are non-detect after evaluation.

**TABLE 4.8**  
**SUMMARY OF CHEMICALS DETECTED IN TRIP BLANKS**

PARAMETER	D001TB0100	D001TB0200	D002TB2200	D002TB4400	D002TB4500	D002TB4600	D002TB4700
1,3-Dimethylbenzene	ND	ND	ND	ND	ND	ND	ND
Acetone	61.7	ND	76.5	ND	ND	ND	ND
Chloroform	ND	5.1	ND	1.2	1.4	1.5	ND
Methylene Chloride	ND	ND	ND	ND	ND	ND	13.1
Xylene	ND	ND	ND	ND	ND	ND	ND

PARAMETER	D002TB4800	D002TB4900	D002TB5000	D002TB5100	D002TB5200	D002TB5300	D002TB5400
1,3-Dimethylbenzene	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND
Chloroform	1	1	5.3	6.7	1.2	2.1	2.9
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND
Xylene	ND	ND	ND	ND	ND	ND	ND

PARAMETER	D002TB5500	D002TB5600	D002TB5700	D002TB5800	D002TB9300	D002TB9400
1,3-Dimethylbenzene	ND	ND	ND	ND	2.3	ND
Acetone	ND	ND	ND	ND	ND	ND
Chloroform	6.1	5.3	1.7	8	ND	ND
Methylene Chloride	ND	ND	ND	ND	ND	ND
Xylene	ND	ND	ND	ND	2.2	1.11

NOTE: Concentrations are in µg/l.

## **5.0 NATURE AND EXTENT OF CONTAMINATION**

The objective of the groundwater investigation at the Lexington Blue-Grass Army Depot (LBAD) was to identify the nature and extent of contamination as it relates to past and present activities undertaken at specific areas of the facility. This objective was accomplished by completing the installation of monitoring wells and instituting a sampling program for the new and existing wells.

Tables 5.1a - 5.1g contain a summary listing of the constituents detected in each monitoring well sampled.

### **5.1 INTRODUCTION**

This section contains discussions and tables summarizing the activities at each area where wells were installed and sampled, and the results of the sampling.

The topics covered in the summary section are:

- Field Investigation Results
- Nature and Extent of Contamination
- Fate and Transport of Contaminants

### **5.2 FIELD INVESTIGATION RESULTS**

Thirty-nine new wells were installed at the LBAD facility in addition to the 11 wells previously installed. Below are discussions of each investigated area, the wells associated with the area, and the analytical results. Tables 5.2a - 5.2g outline the constituents present for each well above MCLs, and Tables 5.3a - 5.3g outline the constituents present for each well above background concentrations.

All inorganics and organic (includes pesticides) constituents detected were compared to MCLs. If no MCL existed for a given parameter, then the secondary MCL was used for comparison. Constituents were considered present above MCLs if they exceeded the present MCL or secondary MCL, or if there was no MCL or secondary MCL. Constituents detected in samples and qualified with a "U" were not used for evaluation purposes. The "U" indicates that the analysis was unconfirmed.



Inorganic and pesticides were also evaluated against background conditions.

### 5.2.1 Background Groundwater Quality

Monitoring well MW07 has been designated as the well suitable for determining site background conditions. MW07 is located in the northern most corner of the Industrial and Sanitary Waste Landfill. The depth of this well is 82 feet.

Tables 5.4 and 5.5 outline the constituents present in this well above MCLs. The following constituents were present above MCLs or secondary MCLs, or detectable concentrations where there is no MCL.

#### Inorganics

Aluminum	Iron	Manganese	Magnesium
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#### Pesticides

DDT

### 5.2.2 Old Landfill (SWMU #4)

The Old Landfill, located along a tributary to Elkhorn Creek, is an unlined area-fill disposal site containing all waste generated at the Lexington facility from 1942 to 1950. Sanitary and industrial waste reported to have been deposited or burned here include flammable liquids, paper, wood, lead batteries, chrome sludge, paints, paint thinner, solvents, and sewage sludge.

Twelve wells: MW02, MW02D, MW03, MW04, MW05, MW19, MW19DD, MW20, MW21, MW29, MW42, and MW47, are located in this area. Total depths of the wells ranged from 23 feet to 80.5 feet. The following contaminants were detected in one or more of the wells exceeding site-background concentrations or MCLs, or detectable concentrations for constituents which do not have an MCL.

#### Inorganics

Aluminum	Beryllium	Iron	Mercury	Thallium
Antimony	Chromium	Lead	Molybdenum	Tin
Arsenic	Cobalt	Magnesium	Nickel	Zinc
Barium	Copper	Manganese	Tellurium	

### Organics

2-Hexanone	2,4-Dimethyl phenol	Methyl isobutyl ketone
1,3-Dimethyl benzene	Acetone	

### Nature and Extent of Contamination

The results of chemical analyses, as displayed in Figures 5.1 and 5.2 and outlined in Tables 5.6 and 5.7, are consistent with other observations of the location and nature of the former landfill operation.

The categories of constituents considered in the following discussion are:

- Inorganics
- Organics

Inorganics were found in seven of the monitoring wells sampled in concentrations ranging up to a maximum of 980,000  $\mu\text{g/l}$ .

The sample collected from MW19DD, located at the western edge of the Old Landfill along the property boundary, has the highest concentrations of the constituents detected except for arsenic and lead. Concentrations of constituents detected at MW19DD range from mercury at 1.54  $\mu\text{g/l}$  to magnesium at 980,000  $\mu\text{g/l}$ . The samples from MW04 and MW47, also located in the western section of the landfill, contain the highest arsenic and lead concentrations of 10.8  $\mu\text{g/l}$  and 106  $\mu\text{g/l}$ , respectively.

Organic constituents are present in five of the wells. Constituents from samples collected in three of those wells have concentrations above MCLs.

The sample from MW19DD has three organic constituents: 2-hexanone, 2,4-dimethyl phenol and methyl isobutyl ketone present above MCLs. 2-Hexanone is present at 5.3  $\mu\text{g/l}$ , 2,4-dimethyl phenol at 20  $\mu\text{g/l}$ , and methyl isobutyl ketone at 5.3  $\mu\text{g/l}$ . The sample collected from MW02, located in the center of the landfill, has a concentration of 1,3-dimethyl benzene present at 3.7  $\mu\text{g/l}$  and acetone at 14  $\mu\text{g/l}$ . The sample collected from MW47 has acetone present at greater than 100  $\mu\text{g/l}$ .

Groundwater flow from this area extends to the west of the landfill into the tributary of North Elkhorn Creek and to the southwest into the same tributary. Monitoring wells, MW19, MW19DD, MW04, and MW42, are in the pathway of the groundwater flow.

Samples from MW19 and MW19DD contain constituents which appear to be results of materials disposed in the landfill. There were no monitoring wells installed outside the property boundary to indicate if the contamination has migrated off site.

Samples from MW04 and MW42 indicate that contamination from the Old Landfill does not extend west of MW19 and MW19DD or to the southwest of the landfill.

### **5.2.3 New Landfill (SWMU #1)**

The New Landfill, located in the northeastern portion of the facility, upstream of the Old Landfill and Industrial and Sanitary Waste Landfill, received all solid waste generated at LBAD between 1971 and 1980. The New Landfill is a trench-and-fill landfill, where paper and office scrap, small quantities of plating sludge, paint waste, infectious waste which was burned prior to burial, and sewage sludge were deposited.

Ten wells: MW22, MW22D, MW23, MW23D, MW43I, MW44IO, MW1132, MW1133, MW1134, and MW1135, are located in this area. Total depths of the wells ranged from 13 feet to 88 feet. The following contaminants were detected in one or more of the wells exceeding site-background concentrations and/or MCLs.

#### Inorganics

Aluminum	Beryllium	Lead	Mercury	Thallium
Arsenic	Chromium	Manganese	Nickel	Zinc
Barium	Iron	Magnesium	Vanadium	

#### Organics

1,3-Dimethyl benzene  
Acetone

## Nature and Extent of Contamination

The results of chemical analyses, as displayed in Figures 5.1 and 5.3 and outlined in Tables 5.8 and 5.9, are consistent with other observations of the location and nature of the former landfill operation.

The categories of constituents considered in the following discussion are:

- Inorganics
- Organics

Inorganics were found above MCLs and/or background in samples collected from five of the monitoring wells sampled in concentrations ranging up to a maximum of 920,000  $\mu\text{g/l}$ .

The sample collected from MW1134, located in the northern section of the New Landfill, has the highest concentrations of the inorganic constituents detected except for barium, beryllium, lead, magnesium, and mercury. Concentrations of constituents detected at MW1134 range from arsenic at 8.78  $\mu\text{g/l}$  to iron at 53,400  $\mu\text{g/l}$ .

The samples from MW23 contain the highest lead concentrations and samples collected from MW23D contain the highest barium, beryllium, magnesium, and mercury concentrations. Both of these wells are located south of the New Landfill. The sample from MW23 contains lead at a concentration of 62.7  $\mu\text{g/l}$  and the sample from MW23D contains barium at 570  $\mu\text{g/l}$ , beryllium at 3.1  $\mu\text{g/l}$ , magnesium at 920,000  $\mu\text{g/l}$ , and mercury at 0.015  $\mu\text{g/l}$ .

Organic constituents are present in three of the wells above MCLs. Acetone is present in the sample collected from MW43I, located east of the landfill, at a concentration greater than 100  $\mu\text{g/l}$ . Samples collected from MW23 and MW23D, located southeast of the landfill, contain concentrations of 1,3-dimethyl benzene at 1.4  $\mu\text{g/l}$  and 4.3  $\mu\text{g/l}$ , respectively.

Groundwater flow from the New Landfill extends to the southeast. Contamination present in MW43I, located east of the landfill appears to be results of waste placed in this area.

#### 5.2.4 Industrial and Sanitary Waste Landfill (SWMU #2567)

The Industrial and Sanitary Waste Disposal Landfill, consisting of four individual disposal sites, is located south of tributary of the Elkhorn Creek. This landfill received solid and hazardous waste generated at the facility between 1950 and 1970. Waste received at the landfill included solvents, paper, and wood which were burned and the residues buried; construction debris; packing material; office waste; transformer fluids possibly containing PCBs; treated and untreated metal plating sludge; sandblasting dust containing chrome; and sewage sludge.

Eighteen wells: MW08, MW08D, MW09, MW18, MW18D, MW32, MW32D, MW33, MW35, MW45, MW46, MW47, MW47D, MW48, MW48D, MW1121, MW1122, and MW1124 are located in this area. Total depths of the wells ranged from 15 feet to 89.5 feet. The following contaminants were detected in one or more of the wells exceeding site-background concentrations and/or MCLs.

##### Inorganics

Aluminum	Cadmium	Iron	Mercury	Zinc
Arsenic	Cobalt	Lead	Nickel	
Barium	Chromium	Manganese	Vanadium	
Beryllium	Copper	Magnesium	Tin	

##### Organics

2-Hexanone	2,4-Dimethyl phenol	Carbon Disulfide
1,1-Dichloroethane	Acetone	Trichloroethene
1,3-Dimethyl benzene	Benzene	Vinyl Chloride

##### Pesticides

delta-Benzene hexachloride

##### Nature and Extent of Contamination

The results of chemical analyses, as displayed in Figures 5.1, 5.2, and 5.3 and outlined in Tables 5.10, 5.11 and 5.12, are consistent with other observations of the location and nature of the former landfill operation.

The categories of constituents considered in the following discussion are:

- Inorganics
- Organics
- Pesticides

Inorganics were found above MCLs and/or background in samples collected from 11 of the monitoring wells in concentrations ranging up to a maximum of 640,000  $\mu\text{g/l}$ .

The sample collected from MW32D, located south of the Industrial and Sanitary Waste Landfill, has the highest concentrations of the inorganic constituents detected except for lead and zinc. Concentrations of constituents detected at MW32D range from mercury at 0.76  $\mu\text{g/l}$  to magnesium at 640,000  $\mu\text{g/l}$ .

Samples from MW33, located southeast of the landfill, and MW18D located east of the landfill, contain the highest lead and zinc concentrations at 25.8  $\mu\text{g/l}$  and 1,900  $\mu\text{g/l}$ , respectively.

Organic constituents are present in 13 of the wells; 12 of those have samples with constituent concentrations above MCLs. The organics were present above MCLs in wells with water level depths ranging from 31 feet to 105 feet.

Samples collected from monitoring wells MW8 and MW8D, located in the southwest portion of the landfill, contain 1,1-dichloroethane present at 9  $\mu\text{g/l}$  and 22  $\mu\text{g/l}$ , respectively. The sample from MW8D also has trichloroethene present at 6.6  $\mu\text{g/l}$ .

The samples from MW18, located east of the landfill, and MW32, located south of the landfill, contain vinyl chloride at concentrations of 17  $\mu\text{g/l}$  and 150  $\mu\text{g/l}$ , respectively. The sample from MW18 also contains 1,3-dimethyl benzene at 16  $\mu\text{g/l}$ , 2,4-dimethyl phenol at 14.8  $\mu\text{g/l}$ , and acetone greater than 100  $\mu\text{g/l}$ .

The sample from MW32D, located south of the landfill, contains 2,4-dimethyl phenol at a concentration of 5.8  $\mu\text{g/l}$  and benzene at a concentration of 6.9  $\mu\text{g/l}$ . The sample from MW45, located northwest of the landfill, has carbon disulfide present at a concentration of 7.9  $\mu\text{g/l}$ . The samples from MW48 and MW48D, located southeast of the landfill, contain acetone at a concentration greater than 100  $\mu\text{g/l}$  and

230 µg/l, respectively. Carbon disulfide and 2-hexanone are also present in the samples from MW48 and MW48D at 7.3 µg/l and 1.1 µg/l, respectively.

Delta-benzene hexachloride is present in the sample from MW18 at a concentration of 0.015 µg/l.

Groundwater in this area flows radially toward the west, south, and southeast.

Contamination present in monitoring wells located to the west of the Industrial and Sanitary Waste Landfill appears to be the result of waste placed in the landfill. There were no monitoring wells installed outside the property boundary to indicate if the contamination has migrated off site. Contamination is present in wells MW48 and MW48D located to the southeast. However, MW47, located south of these wells, only contains 1,3-dimethyl benzene, and MW47D also located south of MW48 and MW48D, does not contain any constituents.

Contamination to the south of the Industrial and Sanitary Waste Landfill extends to MW39D. MW40 located south of MW39D does not contain any constituents representative of the landfill activities.

### **5.2.5 Industrial Waste Lagoons (SWMU #3)**

The Industrial Waste Lagoons, located in the southwest portion of the facility, have been in operation since 1965. Cooling water from Building 7, discharge from a steam-cleaning operation, and plating waste effluent from the Industrial Wastewater Treatment Plant (IWTP), were discharged to the lagoons. Discharge from the IWTP ceased in 1977. Since 1977, the lagoons have been used for pH adjustment of runoff from the coal pile and cooling-water blowdown. Some of the constituents discharged to the lagoons included chromium, brass, copper, cadmium, nickel, silver, acids, alkalies, cyanide, solvents and possibly PCBs.

Ten wells: MW06, MW6D, MW16, MW39D, MW40, MW40D, MW41, MW1051, MW1052, and MW1053, are located in this area. Total depths of the wells ranged from 23 feet to 81.5 feet. The following contaminants were detected in one or more of the wells exceeding site-background concentrations and/or MCLs.

### Inorganics

Aluminum	Cadmium	Iron	Mercury	Tin
Arsenic	Chromium	Lead	Nickel	
Barium	Cobalt	Manganese	Vanadium	
Beryllium	Copper	Magnesium	Thallium	

### Organics

1,3-Dimethyl benzene	bis(2-ethylhexyl)phthalate
2,4-Dimethyl phenol	Carbon Disulfide
Acetone	Phenol
Benzene	

### Pesticides

DDT	alpha-Benzene hexachloride	alpha-Endosulfan
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### Nature and Extent of Contamination

The results of chemical analyses, as displayed in Figures 5.1, 5.2, and 5.3 and outlined in Tables 5.13, 5.14 and 5.15, are consistent with other observations of the location and nature of the former operations of the lagoons.

The categories of constituents considered in the following discussion are:

- Inorganics
- Organics
- Pesticides

Inorganics were found above MCLs and/or background in samples collected from all 10 of the monitoring wells at concentrations ranging up to a maximum of 830,000  $\mu\text{g/l}$ .

The sample collected from MW39, located just east of the lagoons, has the highest concentrations for inorganic constituents which included aluminum, magnesium, mercury, and tin. These constituents range from mercury at 0.299  $\mu\text{g/l}$  to magnesium at 830,000  $\mu\text{g/l}$ . The sample from MW6D, located on the



northern boundary of the lagoons, has the highest concentrations for barium, chromium, copper, lead, manganese, and zinc. These constituents range from copper at 77.6 µg/l to manganese at 17,000 µg/l.

The sample from MW1052, located on the southern boundary of the lagoons, has the highest concentrations of cadmium at 343 µg/l and iron at 152,000 µg/l. The sample from MW16, located west of the lagoons, has the highest concentration for thallium at 196 µg/l.

Organic constituents were present in six of the wells above MCLs.

The sample from MW06, located on the northern boundary of the lagoons, has an acetone concentration at 52 µg/l. The sample from MW1052 has bis(2-ethylhexyl)phthalate present at 13 µg/l and phenol at 5.5 µg/l. Samples from MW39 and MW1051, located south of the lagoons, have acetone present at 100 µg/l and 52 µg/l respectively. Carbon disulfide is present in the sample from MW40D, located south of the lagoons, at 5.6 µg/l.

The sample collected from MW6D, located on the northern boundary of the lagoons, contains 1,3-dimethyl benzene at 1.4 µg/l.

Pesticides are present in three of the wells above MCLs. The sample from MW06 has DDT present at 0.012 µg/l. Alpha-benzene hexachloride is present at 0.003 µg/l in MW1052, and alpha-endosulfan is present in MW16 at 0.5 µg/l.

Groundwater from the Industrial Waste Lagoon area flows south of the lagoons towards MW1051, MW1052, MW40, and MW40D eventually flowing into a creek located south of LBAD.

It appears that contamination from the lagoons is localized to the lagoon area. Wells located south of the lagoons do not indicate that contamination has extended to those points.

#### **5.2.6 Area B**

Area B is located on a drainage path northeast of the water tower. Disposal of industrial waste took place at Area B.

Two wells, MW1123 and MW45, are located in this area. Total depth of these wells is 37 feet and 42 feet, respectively. The following contaminants detected in these wells exceeded site-background concentrations and/or MCLs.

Inorganics

Aluminum	Barium	Cobalt	Manganese	Vanadium
Antimony	Beryllium	Iron	Magnesium	Zinc
Arsenic	Chromium	Lead	Nickel	

Organics

1,3-Dimethyl benzene

Phenol

Carbon disulfide

Pesticides

DDT

Nature and Extent of Contamination

The results of chemical analyses, as displayed in Figures 5.1, 5.2, and 5.3 and outlined in Tables 5.16, 5.17, and 5.18, are consistent with other observations of the location and nature of the former landfill operation.

The categories of constituents considered in the following discussion are:

- Inorganics
- Organics
- Pesticides

Inorganics were found above MCLs and/or background in the sample collected from MW1123 and MW45 in concentrations ranging up to a maximum of 84,000 µg/l.

The organic constituents present in these wells above MCLs are phenol at a concentration of 17 µg/l, 1,3-dimethyl benzene at 2.2 µg/l, and carbon disulfide at 7.9 µg/l.

Pesticides found are DDT at a concentration of 0.008 µg/l and dieldrin at 0.017 µg/l.

### 5.2.7 Area C

Area C may have been a rubble disposal area. Aerial photographs indicate that disposal occurred in this area over time.

One well, MW1009, is located in this area at the most eastern corner of the area. The depth of this well is unknown. The following contaminants were detected in the samples collected from this well exceeding site-background concentrations and/or MCLs.

#### Inorganics

Aluminum	Chromium	Manganese	Vanadium
Arsenic	Iron	Magnesium	Zinc
Beryllium	Lead	Nickel	

#### Organics

1,3-Dimethyl benzene

Chloromethane

#### Nature and Extent of Contamination

The results of chemical analyses, as displayed in Figures 5.1 and 5.2 and outlined in Tables 5.19 and 5.20, are consistent with other observations of the location and nature of the former landfill operation, although well number MW1009 appears to be upgradient from Area C.

The categories of constituents considered in the following discussion are:

- Inorganics
- Organics

Inorganics were found above MCLs and/or background in the sample collected from MW1009 at concentrations ranging up to a maximum of 24,300 µg/l. MW1009 is an existing well with a depth of 50 feet. It is also the only well in this area.

The organic constituents present in the sample from this well above MCLs are chloromethane at a concentration of 4.4 µg/l and 1,3-dimethyl benzene at 1.3 µg/l.

#### **5.2.8 Significance and Implications**

The groundwater at LBAD was divided into two portions: the northern portion which encompasses the New Landfill and Area C, and the southern portion which includes the Old Landfill, Industrial and Sanitary Waste Landfill, Area B, and Industrial Waste Lagoons. The division of the groundwater into two different portions was essential in determining the risks related to the site and for treatment of the groundwater during a corrective measures study.

##### **Northern Portion**

Metals in groundwater in the northern portion of LBAD contributed to carcinogenic risk levels on the order of 6E-5, 3E-4, and 1E-4 for the future hypothetical residential short term adult, long term adult, and child exposures, respectively. The short term and long term future occupational exposures resulted in risks of 6E-5 and 1E-4 respectively.

With respect to noncarcinogenic effects, hazard levels of 16.2 for short term adult, 53.1 for long term adult, and 35.5 for child were also a result of exposure to metals in groundwater. Likewise, hazard levels of 5.72 and 18.8 were associated with short term and long term occupational exposure to metals in groundwater, respectively.

##### **Southern Portion**

Carcinogenic risk levels in the southern portion of LBAD were associated with exposure to vinyl chloride and metals in groundwater. The future hypothetical residential short term adult, long term adult, and child risk values were 9E-5, 6E-4, and 2E-4 respectively. The short term and long term future occupational risk values were 3E-5 and 2E-4 respectively.

The noncarcinogenic hazard values were 54.7, 79.8, and 120 for the future hypothetical residential short term adult, long term adult, and child respectively. Similarly, the short term and long term occupational exposures were associated with hazard levels of 19.2 and 28.1 respectively. The noncarcinogenic values were primarily a result of exposure to metals in groundwater.

### **5.3 POTENTIAL CONTAMINATION SOURCES**

This section discusses the potential sources of the contamination present in the wells. The constituents of concern are those which exceeded MCLs and/or background concentrations. Vertical and horizontal extent of contamination will also be discussed.

Solvents, paints, paint thinner, metal plating sludge, sand-blasting dust, paper, wood, office scrap, and sewage sludge were disposed throughout the site. The following contaminants which were detected during the investigation are representative of the materials deposited over the years: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, magnesium, manganese, nickel, thallium, vanadium, zinc, 2-hexanone, 2,4-dimethyl phenol, benzene, chloromethane, acetone, methyl isobutyl ketone, trichloroethene, 1,1-dichloroethane, carbon disulfide, and vinyl chloride.

Three additional contaminants: molybdenum, tellurium, and tin, were detected in one sample from the Old Landfill. The presence of molybdenum, tellurium, and tin at the Old Landfill is unclear as they were detected in only one well at this area.

#### **5.3.1 Background**

MW07, located at the northern edge of the Industrial and Sanitary Waste Landfill, has been designated as the well that best demonstrates background conditions. Contamination present in this well includes four inorganics and one pesticide.

The inorganics present; aluminum, beryllium, iron, manganese, and magnesium, are all naturally occurring metals. However, because they exceed MCLs, it is believed the material disposed at the Industrial and Sanitary Landfill is the probable source of the elevated concentrations of these metals.

The potential source for the pesticide present, DDT, is most likely from maintenance of the grounds at the facility. Although, empty containers of pesticides used for maintenance could also have been disposed at the landfill.

### **5.3.2 Old Landfill (SWMU #4)**

Twelve wells; MW02, MW02D, MW03, MW04, MW05, MW19, MW19DD, MW20, MW21, MW29, MW42, and MW47, are located in this area. Contamination present in this well includes 16 inorganics, seven organics, and three pesticides.

The materials disposed of at the Old Landfill, included flammable liquids, paper, wood, lead batteries, chrome sludge, paints, paint thinner, solvents, and sewage sludge. All the inorganics present, except for molybdenum, tellurium, and tin, are probably related to the material disposed of at this area. The source of molybdenum, tellurium, and tin is unclear, however, it is possible they originated from the Old Landfill.

The inorganics, found in eight of the wells above MCLs and/or background, include aluminum, antimony, beryllium, chromium, cobalt, iron, lead, manganese, magnesium, molybdenum, nickel, vanadium, tellurium, tin, thallium, and zinc. All of these metals are naturally occurring, but because they are present at such elevated levels, contamination is more likely to be the cause of their presence.

The organics present; 2,4-dimethyl phenol, 2-hexanone, acetone, benzene, bis(2-ethylhexyl)phthalate, carbon disulfide, and phenol, are all representative of the paints, paint thinner, solvents, and flammable liquids disposed at this area. The only organic that may have another source for its presence is acetone. Because acetone was present in only one of the wells at a concentration greater than 100  $\mu\text{g/l}$ , it is possible it did not originate from the Old Landfill.

The three pesticides present; DDT, alpha-benzene hexachloride, and alpha-endosulfan, are probably related to maintenance of the grounds at the facility. However, it is possible that empty containers having residue from the pesticides were disposed at this area.

### **5.3.3 New Landfill (SWMU #1)**

Ten wells; MW22, MW22D, MW23, MW23D, MW43I, MW43IO, MW1132, MW1133, MW1134, and MW1135, are located in this area. Contamination present in this well includes 15 inorganics, and two organics.

Materials disposed of at the New Landfill include paper and office scrap, plating sludge, paint waste, infectious waste burned prior to burial, and sewage sludge. All the inorganics present are representative of these materials, which indicate that the landfill is the potential source of contamination.

The inorganics, found in only three of the wells above MCLs and/or background, include aluminum, arsenic, barium, beryllium, chromium, copper, iron, lead, manganese, magnesium, mercury, nickel, vanadium, thallium, and zinc. All of these metals are naturally occurring, but because they are present at such elevated levels, contamination originating from the materials disposed in this area is more likely to be the cause of their presence.

The organics, 1,3-dimethyl benzene and acetone, are also representative of the plating sludge, paper, and paint waste disposed at this area.

#### **5.3.4 Industrial and Sanitary Waste Landfill (SWMU #2567)**

Eighteen wells: MW08, MW08D, MW09, MW18, MW18D, MW32, MW32D, MW33, MW35, MW45, MW46, MW47, MW47D, MW48, MW48D, MW1121, MW1122, and MW1124, are located in this area. Contamination present in the wells includes 14 inorganics, and seven organics.

Materials disposed at this landfill include solvents, paper, and wood, which were burned and their residues buried; construction debris; office waste; packing material; treated and untreated metal plating sludge; sand-blasting dust containing chrome; sewage sludge; and transformer fluids possibly containing PCBs.

The inorganics found in 12 of the wells above MCLs and/or background, include aluminum, barium, beryllium, chromium, copper, iron, lead, manganese, magnesium, mercury, nickel, vanadium, tin, and zinc. All of these metals are naturally occurring, but because they are present at such elevated levels, contamination originating from the materials disposed in this area is more likely to be the cause of their presence.

The organics; 1,1-dichloroethane, 2,4-dimethyl phenol, acetone, benzene, carbon disulfide, trichloroethene, and vinyl chloride, were present in seven of the wells. All the organics present, except for the vinyl chloride, are representative of the materials disposed at this landfill. A soil gas survey was conducted and the source of the vinyl chloride was found to be the northern portion of the landfill. The

vinyl chloride is believed to be a breakdown product of constituents present in the solvents after they were burned.

#### **5.3.5 Area B**

Two wells, MW1123 and MW45, are located in this area. Contamination present in these wells includes 12 inorganics, two organics, and one pesticide.

It is believed that industrial waste was disposed in this area. The type of industrial waste disposed is unclear, however, it could include office scrap, waste solvents, and sludges.

The inorganics found above MCLs and/or background, include aluminum, antimony, barium, beryllium, chromium, cobalt, iron, lead, manganese, magnesium, vanadium, and zinc. All of these metals are naturally occurring, but because they are present at such elevated levels, contamination originating from the material disposed in this area is more likely to be the cause of their presence.

Phenol and carbon disulfide were the only two organics present in MW1123 and MW45. These organics could possibly be a byproduct of waste solvents or treated wood materials if these were disposed at this area.

The DDT present most likely originated from routine maintenance of the grounds. However, it is possible that empty containers having pesticide residue were disposed at this area.

#### **5.3.6 Area C**

One well, MW1009, is located in this area. Contamination present in this well includes 10 inorganics and one organic.

It is believed that Area C may have been a rubble landfill. The materials disposed at this area are unknown.

The inorganics found above MCLs and/or background include; aluminum, beryllium, chromium, iron, lead, manganese, magnesium, nickel, vanadium, and zinc. All of these metals are naturally occurring,



but because they are present at such elevated levels, contamination believed to be originating from Area C, is more likely to be the cause of their presence.

Only one organic, chloromethane, was detected in MW1009. It is unclear as to the source of this constituent. Because the type of material disposed here is unknown, it is difficult to determine if Area C is the potential source. In addition, MW1009 presently appears to be upgradient of Area C, therefore it is possible that the constituents present are originating off-site.

#### **5.4 FATE AND TRANSPORT**

The groups of chemicals found in significant concentrations in the LBAD ground water included metals, volatile organic compounds, and semivolatile organic compounds (PAHs, pesticides and PCBs). The fate and transport of these chemicals from source locations to other environmental media follow some general patterns for the SWMUs and other areas investigated at LBAD.

The persistence of organic compounds in any given environment is primarily a function of degradability, volatility, and solubility.

Biodegradation of organic compounds is controlled by a variety of factors including chemical structure of the compound and its susceptibility to biological breakdown; presence of microorganisms capable of metabolizing parts of the compound of concern; and nutrient availability.

The solubility of an organic compound refers to the relative partitioning into water as compared to an organic solvent such as octanol. The solubilities of the organic contaminants present in the groundwater at LBAD influence on the fate and transport of the compounds. The migration of dissolved organics would follow groundwater flow direction. The migration of organic compounds adsorbed to particulates or in nonaqueous phase may or may not follow the groundwater flow direction (depending on the density of the nonaqueous organic phase).

The VOCs identified at LBAD; acetone, benzene, 1,3-dimethyl phenol, 2,4-dimethyl benzene, carbon disulfide, 1,1-dichloroethane, vinyl chloride, and methyl isobutyl ketone, are generally characterized by high volatilization, varying degrees of solubility and biodegradability. Biodegradation of VOCs indicate that not all VOCs are subject to biodegradation whereas some are susceptible under a variety of condition.

Volatile organic compounds differ widely in their susceptibility to biological degradation under a variety of conditions.

Volatile organic compounds are also subject to biotransformation in water through aerobic and/or anaerobic degradation.

Semi-volatile organic compounds released into the atmosphere may be subject to short- and long-range transport and removal by wet and dry deposition. Semi-volatile compounds have lower vapor pressures and are less likely to vaporize compared to volatile organic compounds. Some lipophilic semi-volatile compounds, such as pesticides and PCBs, accumulate to a significant degree in aquatic organisms and terrestrial animals exposed through the food chain.

The environmental transport and fate of metals is influenced by the oxidation state of the metal compound. Metals may occur naturally or adsorb to suspended organic matter in water. With the exception of organic mercury, most metals do not bioaccumulate in aquatic or terrestrial food chains to a significant extent. Metals which are in water soluble chemical form could be expected to move readily through groundwater.

**TABLE 5.1a Summary of Constituents Present in the Groundwater at Area B and Area C**

PARAMETER	A00BMW1123 12/6/91	A00BMW1123 9/3/92	A00CMW1009 12/5/91	A00CMW1009 9/2/92	S2567MW4500 8/21/92
Aluminum	6450	65100	24300	15900	171
Antimony	73.2	ND	ND	ND	ND
Arsenic	ND	10.9	ND	3.32	ND
Barium	62.4	307	84.3	48.3	177
Beryllium	ND	3.02	1.65	ND	ND
Boron	ND	305	ND	389	276
Cadmium	ND	ND	ND	ND	ND
Calcium	162000	210000	80400	33600	79600
Chromium	71	139	34.4	42.5	ND
Cobalt	ND	35.9	ND	ND	ND
Copper	ND	55.5	25.7	ND	ND
Iron	17600	84000	37800	16400	132
Lead	11.6	95.4	25.1	19.3	ND
Magnesium	21000	40600	22700	15500	24200
Manganese	4740	5120	764	288	53.2
Mercury	ND	ND	ND	ND	ND
Molybdenum	ND	ND	ND	ND	ND
Nickel	ND	97.9	38.3	ND	ND
Potassium	4310	26600	11600	8700	6310
Sodium	10100	17400	55000	94000	29300
Tellurium	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND
Tin	ND	ND	ND	ND	ND
Vanadium	ND	85.4	42.2	ND	ND
Zinc	48.4	244	103	66.7	77
Aldrin	ND	ND	ND	ND	ND
Alpha – Benzene Hexachloride	ND	ND	ND	ND	ND
Alpha – Endosulfan	ND	ND	ND	ND	ND
Beta – Benzene Hexachloride	ND	ND	ND	ND	ND
Beta – Endosulfan	ND	ND	ND	ND	ND
DDT	0.008 C	ND	0.005 U	ND	ND
DDD	ND	ND	ND	ND	ND
DDE	ND	ND	ND	ND	ND
Delta – benzene Hexachloride	ND	ND	0.004 U	ND	ND
Dieldrin	0.017 U	0.297 U	ND	ND	ND
Endrin	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND
Heptachlor Epoxide	ND	ND	ND	ND	ND
Isodrin	ND	ND	ND	0.004 U	ND
Lindane	ND	ND	0.012 U	ND	ND
2 – Hexanone	ND	ND	ND	ND	ND
1,1 – Dichloroethane	ND	ND	ND	ND	ND
1,2 – Dichloroethenes	ND	ND	ND	ND	ND
1,3 – Dimethylbenzene	ND	2.2	ND	1.3	ND
2,4 – Dimethylphenol	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND
Benzene	ND	ND	1	ND	ND
Bis(2 – ethylhexyl) phthalate	ND	ND	ND	ND	ND
Carbon Disulfide	ND	ND	ND	ND	7.9 R
Chloromethane	ND	ND	4.4	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND
Methyl Isobutyl Ketone	ND	ND	ND	ND	ND
Phenol	ND	17	ND	ND	ND
Tetrachloroethane	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND
Xylenes	ND	ND	ND	ND	ND

**Key:**
**All results are in ug/l**
**ND – Not Detected**
**U – Unconfirmed Analysis**
**C – Confirmed Analysis**

**TABLE 5.1b Summary of Constituents Present in the Groundwater at the New Landfill**

PARAMETER	S001MW1134 12/5/91	S001MW2300 8/19/92	S001MW23D0 8/19/92	S001MW4310 8/19/92	S001MW4410 8/19/92
Aluminum	22900	17000	10800	1060	1980
Antimony	ND	ND	ND	ND	ND
Arsenic	8.78	5.93 H	ND	ND	ND
Barium	183	173	570	29.8	27.4
Beryllium	1.73	ND	3.1	ND	ND
Boron	ND	ND	ND	535	450
Cadmium	ND	ND	ND	ND	ND
Calcium	174000	510000	*	139000	55900
Chromium	47.1	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND
Copper	36.2	28.9	33.7	ND	ND
Iron	53400	29600	17100	1560	1180
Lead	18.6	62.7	30	ND	ND
Magnesium	54600	46200	920000	19300	29700
Manganese	1700	935	1330	70.3	34.5
Mercury	ND	ND	0.105	ND	ND
Molybdenum	ND	ND	ND	ND	ND
Nickel	49.7	41.4	ND	ND	ND
Potassium	28200	11900	154000	9260	31100
Sodium	*	110000	*	120000	62000
Tellurium	ND	ND	ND	ND	ND
Thallium	189	ND	ND	ND	ND
Tin	ND	ND	ND	ND	ND
Vanadium	36.9	ND	ND	ND	ND
Zinc	111	56.1	44.2	30.9	40.7
Aldrin	ND	ND	ND	ND	ND
Alpha - Benzene Hexachloride	ND	ND	ND	ND	ND
Alpha - Endosulfan	ND	ND	ND	ND	ND
Beta - Benzene Hexachloride	ND	ND	ND	ND	ND
Beta - Endosulfan	ND	ND	ND	ND	ND
DDT	ND	ND	ND	ND	ND
DDD	ND	ND	ND	ND	ND
DDE	ND	ND	ND	ND	ND
Delta - benzene Hexachloride	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	0.083 U	ND
Heptachlor	ND	ND	ND	0.05 U	ND
Heptachlor Epoxide	ND	ND	ND	ND	ND
Isodrin	ND	ND	ND	0.056 U	0.013 U
Lindane	ND	ND	ND	ND	ND
2 - Hexanone	ND	ND	ND	ND	ND
1,1 - Dichloroethane	ND	ND	ND	ND	ND
1,2 - Dichloroethenes	ND	ND	ND	ND	ND
1,3 - Dimethylbenzene	ND	1.4	4.3	ND	ND
2,4 - Dimethylphenol	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND
Benzene	ND	ND	2.8	>100	ND
Bis(2 - ethylhexyl) phthalate	ND	ND	ND	1.24	ND
Carbon Disulfide	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND
Methyl Isobutyl Ketone	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND
Tetrachloroethane	ND	ND	ND	ND	ND
Toluene	ND	2.6	3.7	3.1	ND
Trichloroethene	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND
Xylenes	ND	ND	4.4	ND	ND

**Key:**

All results are reported in ug/l

ND - Not Detected

U - Unconfirmed Analysis

C - Confirmed Analysis

**TABLE 5.1c Summary of Constituents Present in the Groundwater Monitoring Wells at the Industrial Waste Lagoons**

PARAMETER	S003MW0600 12/11/91	S003MW1051 11/24/91	S003MW1051 9/1/92	S003MW40D0 8/21/92	S003FD40D0 8/21/92	S003MW1052 12/6/91
Aluminum	2470	3500	ND	2520	1620	34400
Antimony	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND	ND	ND
Barium	99.9	161	145	106	105	327
Beryllium	ND	ND	ND	ND	ND	2.86
Boron	ND	ND	388	1110	1180	ND
Cadmium	ND	7.22	ND	ND	ND	343
Calcium	165000	118000	95300	131000	115000	240000
Chromium	28.7	18.1	ND	ND	ND	173
Cobalt	ND	ND	ND	ND	ND	28
Copper	ND	ND	ND	ND	ND	156
Iron	3200	8940	624	4080	2580	152000
Lead	ND	5.55	ND	ND	ND	27.1
Magnesium	54200	31200	29600	43000	46600	55300
Manganese	306	342	150	292	201	6670
Mercury	ND	ND	ND	ND	ND	ND
Molybdenum	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	111
Potassium	6160	4940	3520	10900	12000	12000
Sodium	48900	23200	21800	190000	220000	40100
Tellurium	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND
Tin	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	53.8
Zinc	29.5	36.2	ND	58.3	72.3	386
Aldrin	ND	ND	ND	ND	ND	ND
Alpha - Benzene Hexachloride	0.009 U	0.004 U	ND	ND	ND	0.003 C
Alpha - Endosulfan	ND	ND	ND	ND	ND	ND
Beta - Benzene Hexachloride	ND	ND	ND	ND	ND	0.01 U
Beta - Endosulfan	ND	ND	ND	ND	ND	ND
DDT	0.012 C	ND	ND	ND	ND	0.017 U
DDD	ND	ND	ND	ND	ND	ND
DDE	0.006 U	ND	ND	ND	ND	0.005 U
Delta - benzene Hexachloride	ND	ND	ND	ND	ND	0.004 U
Dieldrin	ND	ND	ND	ND	ND	0.044 U
Endrin	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	ND	ND	ND	ND	ND	ND
Isodrin	ND	0.004 U	ND	ND	ND	ND
Lindane	0.005 C	ND	ND	ND	ND	0.008 U
2 - Hexanone	ND	ND	ND	ND	ND	ND
1,1 - Dichloroethane	ND	ND	ND	ND	ND	ND
1,2 - Dichloroethenes	ND	ND	ND	ND	ND	ND
1,3 - Dimethylbenzene	1.8	ND	ND	ND	ND	ND
2,4 - Dimethylphenol	ND	ND	ND	ND	ND	ND
Acetone	52	52	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND
Bis(2 - ethylhexyl) phthalate	ND	ND	ND	ND	ND	13
Carbon Disulfide	ND	ND	ND	5.6 R	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND
Ethylbenzene	1.1	ND	ND	ND	ND	ND
Methyl Isobutyl Ketone	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	5.5
Tetrachloroethane	ND	ND	ND	ND	ND	ND
Toluene	3.7	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND
Xylenes	3.1	ND	ND	ND	ND	ND

Key:  
All results are reported in ug/l  
ND - Not Detected  
U - Unconfirmed Analysis  
C - Confirmed Analysis

**TABLE 5.1c (cont.) Summary of Constituents Present in the Groundwater at the Industrial Waste Lagoons**

PARAMETER	S003FD1052 12/6/91	S003MW1052 9/2/92	S003FD1052 9/2/92	S003MW1053 11/24/91	S003MW1600 12/10/91	S003MW1600 9/2/92
Aluminum	ND	3840	9150	143	2390	262
Antimony	ND	ND	ND	ND	ND	ND
Arsenic	ND	2.9	3.89	ND	ND	ND
Barium	ND	83.7	143	168	262	74
Beryllium	ND	ND	ND	ND	ND	ND
Boron	ND	257	274	ND	ND	271
Cadmium	ND	147	291	ND	ND	ND
Calcium	ND	153000	160000	93900	141000	107000
Chromium	ND	41.8	119	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND	ND
Copper	ND	ND	33.9	ND	ND	ND
Iron	ND	18600	47100	1020	19300	1570
Lead	32.1	6.71	14.6	ND	9.32	ND
Magnesium	ND	30800	32700	36200	35000	32400
Manganese	ND	1610	4000	42.3	377	141
Mercury	ND	ND	ND	ND	ND	ND
Molybdenum	ND	ND	ND	ND	ND	ND
Nickel	ND	39.7	79.6	ND	ND	ND
Potassium	ND	3610	5350	4280	3090	4010
Sodium	ND	31200	31600	32900	19600	40800
Tellurium	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	196	ND
Tin	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND
Zinc	ND	110	161	ND	24.2	ND
Aldrin	ND	ND	ND	ND	ND	ND
Alpha - Benzene Hexachloride	0.008 U	ND	ND	ND	ND	ND
Alpha - Endosulfan	ND	ND	ND	ND	>0.5	ND
Beta - Benzene Hexachloride	ND	ND	ND	ND	ND	ND
Beta - Endosulfan	ND	ND	ND	ND	0.237 U	ND
DDT	0.017 U	ND	ND	0.007 U	ND	ND
DDD	ND	ND	ND	ND	ND	ND
DDE	0.005 U	ND	ND	ND	ND	ND
Delta - benzene Hexachloride	0.008 U	ND	ND	ND	ND	ND
Dieldrin	0.085 U	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	ND	ND	ND	ND	ND	ND
Isodrin	ND	0.004 U	0.004 U	ND	0.007 U	0.003 U
Lindane	0.014 U	ND	ND	ND	ND	ND
2 - Hexanone	ND	ND	ND	ND	ND	ND
1,1 - Dichloroethane	ND	ND	ND	ND	ND	ND
1,2 - Dichloroethenes	ND	ND	ND	ND	ND	ND
1,3 - Dimethylbenzene	ND	ND	ND	ND	ND	ND
2,4 - Dimethylphenol	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND
Bis(2 - ethylhexyl) phthalate	ND	ND	ND	ND	ND	ND
Carbon Disulfide	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND
Methyl Isobutyl Ketone	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND
Tetrachloroethane	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	1.7	ND
Trichloroethene	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND
Xylenes	ND	ND	ND	ND	ND	ND

**Key:**

All results are reported in ug/l

ND - Not Detected

U - Unconfirmed Analysis

C - Confirmed Analysis

**TABLE 5.1c (cont.) Summary of Constituents Present in the Groundwater at the Industrial Waste Lagoons**

PARAMETER	S003MW39D0 8/21/92	S003MW4000 8/20/92	S003FD4000 8/20/92	S003MW4100 8/19/92	S003MW6D00 8/21/92
Aluminum	94800	666	746	605	87600
Antimony	ND	ND	ND	ND	ND
Arsenic	25	ND	ND	ND	ND
Barium	849	266	205	38.5	911
Beryllium	36.5	ND	ND	ND	36.5
Boron	2420	557	393	408	1930
Cadmium	ND	ND	ND	ND	ND
Calcium	*	115000	93200	88200	*
Chromium	210	ND	ND	ND	273
Cobalt	69	ND	ND	ND	26.1
Copper	66.2	ND	ND	ND	77.6
Iron	135000	1680	1260	793	111000
Lead	180	ND	ND	ND	470
Magnesium	830000	37500	28900	9930	750000
Manganese	14000	157	142	1080	17000
Mercury	0.299	ND	ND	ND	0.174
Molybdenum	ND	ND	ND	ND	ND
Nickel	169	ND	ND	ND	152
Potassium	125000	5680	5410	2530	122000
Sodium	*	48900	37800	15800	*
Tellurium	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND
Tin	102	ND	ND	ND	94.9
Vanadium	523	ND	ND	ND	523
Zinc	1470	34.9	27	43.1	1850
Aldrin	ND	ND	ND	ND	ND
Alpha - Benzene Hexachloride	ND	ND	ND	ND	ND
Alpha - Endosulfan	ND	ND	ND	ND	ND
Beta - Benzene Hexachloride	ND	ND	ND	ND	ND
Beta - Endosulfan	ND	ND	ND	ND	ND
DDT	ND	ND	ND	ND	ND
DDD	ND	ND	ND	ND	ND
DDE	ND	ND	ND	ND	ND
Delta - benzene Hexachloride	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND
Heptachlor Epoxide	ND	ND	ND	ND	ND
Isodrin	ND	ND	ND	ND	ND
Lindane	ND	ND	ND	ND	ND
2 - Hexanone	ND	ND	ND	ND	ND
1,1 - Dichloroethane	ND	ND	ND	ND	ND
1,2 - Dichloroethenes	ND	ND	ND	ND	ND
1,3 - Dimethylbenzene	1.6	ND	ND	ND	14
2,4 - Dimethylphenol	ND	ND	ND	ND	13
Acetone	> 100	ND	ND	ND	> 100
Benzene	ND	ND	ND	ND	33
Bis(2 - ethylhexyl) phthalate	ND	ND	ND	ND	ND
Carbon Disulfide	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	6.8
Methyl Isobutyl Ketone	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND
Tetrachloroethane	ND	ND	ND	ND	ND
Toluene	2.7	ND	ND	ND	69
Trichloroethene	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND
Xylenes	2.3	ND	ND	ND	110

**Key:**
**All results are reported in ug/l**
**ND - Not Detected**
**U - Unconfirmed Analysis**
**\* - This concentration is greater than 115000 ug/l**



**TABLE 5.1d Summary of Constituents Present in the Groundwater at the Old Landfill**

PARAMETER	S004MW0200 12/10/91	S004MW0300 12/10/91	S004MW0400 12/4/91	S004MW0400 9/2/92	S004FD0500 12/9/91	S004MW4700 8/21/92
Aluminum	992	1360	22900	2710	326	44200
Antimony	ND	ND	63	ND	ND	ND
Arsenic	3.89	ND	10.8	ND	ND	ND
Barium	78.7	69.3	300	189	74.7	194
Beryllium	ND	ND	1.66	ND	ND	1.1
Boron	ND	ND	ND	ND	ND	367
Cadmium	ND	ND	ND	ND	ND	ND
Calcium	130000	60800	172000	89700	102000	26600
Chromium	ND	34.8	32.8	ND	ND	41.6
Cobalt	ND	ND	32.6	ND	ND	ND
Copper	24.2	30.3	41.1	ND	23.1	57.2
Iron	3590	3070	51200	5560	2180	39100
Lead	21.3	9.12	101	9.65	ND	106
Magnesium	36600	9870	18400	13000	13600	8440
Manganese	162	74.2	1000	361	193	324
Mercury	ND	0.127	ND	ND	0.116	0.101
Molybdenum	ND	ND	ND	ND	ND	ND
Nickel	ND	55.6	ND	ND	ND	59.3
Potassium	4860	1690	5310	2700	1610	7630
Sodium	47000	89000	27800	70000	13000	180000
Tellurium	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND
Tin	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	39.8	ND	ND	34.1
Zinc	25.6	32.3	119	35.1	32.2	154
Aldrin	ND	ND	ND	ND	ND	ND
Alpha - Benzene Hexachloride	ND	ND	ND	ND	ND	ND
Alpha - Endosulfan	ND	ND	ND	ND	ND	ND
Beta - Benzene Hexachloride	ND	ND	ND	ND	ND	ND
Beta - Endosulfan	ND	ND	ND	ND	ND	ND
DDT	ND	ND	ND	ND	ND	ND
DDD	ND	ND	ND	ND	ND	ND
DDE	ND	ND	ND	ND	ND	ND
Delta - benzene Hexachloride	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND
Heptachlor	ND	0.004 U	0.039 U	ND	0.007 U	ND
Heptachlor Epoxide	ND	ND	ND	ND	ND	ND
Isodrin	ND	0.004 U	ND	0.009 U	0.008 U	ND
Lindane	ND	ND	ND	ND	ND	ND
2 - Hexanone	ND	ND	ND	ND	ND	ND
1,1 - Dichloroethane	ND	ND	ND	ND	ND	ND
1,2 - Dichloroethenes	ND	ND	ND	ND	ND	ND
1,3 - Dimethylbenzene	3.7	ND	ND	ND	ND	14
2,4 - Dimethylphenol	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	> 100
Benzene	1.9	ND	ND	ND	ND	4.8
Bis(2 - ethylhexyl) phthalate	ND	ND	ND	ND	ND	ND
Carbon Disulfide	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND
Ethylbenzene	2.1	ND	ND	3.9	ND	7.2
Methyl Isobutyl Ketone	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND
Tetrachloroethane	ND	ND	ND	ND	ND	ND
Toluene	11	ND	ND	ND	ND	37
Trichloroethene	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND
Xylenes	3.4	ND	ND	ND	ND	13

**Key:**

All results are in ug/l

ND - Not Detected

R - Analysis required for reporting purposes but not certified

\* - For calcium this concentration is > 131000 ug/l and sodium its > 220000 ug/l



**TABLE 5.1d (cont.) Summary of Constituents Present in the Groundwater at the Old Landfill**

PARAMETER	S004MW1900 5/26/92	S004FD1900 5/26/92	S004MW19DD 9/10/92	S004MW4200 8/19/92	S004FD4200 8/19/92
Aluminum	1220	1560	350000	285	322
Antimony	ND	ND	217	ND	ND
Arsenic	ND	ND	ND	ND	ND
Barium	53.9	59.7	1870	72.6	76.2
Beryllium	ND	ND	18.2	ND	ND
Boron	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND
Calcium	86400	89300	*	78200	81100
Chromium	ND	ND	448	ND	ND
Cobalt	ND	ND	186	ND	ND
Copper	ND	ND	257	ND	ND
Iron	3060	3600	342000	2380	2590
Lead	ND	7.58	ND	ND	ND
Magnesium	13900	14300	980000	11600	12000
Manganese	252	270	65000	124	129
Mercury	ND	ND	1.54	ND	ND
Molybdenum	ND	ND	58.8	ND	ND
Nickel	ND	ND	427	ND	ND
Potassium	ND	1660	83500	1830	1780
Sodium	12800	13300	*	20300	21100
Tellurium	ND	ND	211	ND	ND
Thallium	ND	ND	437	ND	ND
Tin	ND	ND	62.9	ND	ND
Vanadium	ND	ND	237	ND	ND
Zinc	29.2	21.6	1140	ND	ND
Aldrin	ND	ND	ND	ND	ND
Alpha – Benzene Hexachloride	ND	ND	ND	ND	ND
Alpha – Endosulfan	ND	ND	ND	ND	0.004 U
Beta – Benzene Hexachloride	ND	ND	ND	ND	ND
Beta – Endosulfan	0.237 U	ND	ND	ND	ND
DDT	ND	ND	ND	ND	ND
DDD	ND	ND	ND	ND	ND
DDE	ND	ND	ND	ND	ND
Delta – benzene Hexachloride	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND
Heptachlor	0.004 U	ND	ND	ND	ND
Heptachlor Epoxide	ND	ND	ND	ND	ND
Isodrin	ND	ND	ND	ND	ND
Lindane	ND	ND	ND	ND	ND
2 – Hexanone	ND	ND	5.3 R	ND	ND
1,1 – Dichloroethane	ND	ND	ND	ND	ND
1,2 – Dichloroethenes	ND	ND	ND	ND	ND
1,3 – Dimethylbenzene	ND	ND	ND	ND	1.11
2,4 – Dimethylphenol	ND	ND	20	ND	ND
Acetone	ND	ND	ND	ND	ND
Benzene	ND	ND	0.78	ND	ND
Bis(2 – ethylhexyl) phthalate	ND	ND	ND	ND	ND
Carbon Disulfide	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND
Methyl Isobutyl Ketone	ND	ND	5.3	ND	ND
Phenol	ND	ND	ND	ND	ND
Tetrachloroethane	ND	ND	ND	ND	ND
Toluene	1.1	1.3	ND	ND	ND
Trichloroethene	1.1	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND
Xylenes	ND	ND	42	ND	ND

**Key:**

R – results are in ug/l  
 ND – Not Detected  
 U – Unconfirmed Analysis

**TABLE 5.1e Summary of Constituents Present in the Groundwater at the Industrial and Sanitary Waste Landfill**

PARAMETER	S2567MW070 12/12/91	S2567MW080 12/16/91	S2567MW090 12/17/91	S2567MW122 12/6/91	S2567MW124 12/11/91	S2567MW8D0 8/22/92	B004MW4700 8/22/92
Aluminum	3310	1730	952	3000	4340	512	ND
Antimony	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND	ND	ND	ND
Barium	211	184	307	350	113	174	ND
Beryllium	ND	ND	ND	ND	ND	ND	ND
Boron	ND	ND	ND	ND	ND	613	ND
Cadmium	ND	ND	ND	ND	ND	ND	ND
Calcium	82000	143000	82600	88000	123000	169000	ND
Chromium	ND	36.4	ND	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND	ND	ND
Copper	100	ND	ND	ND	ND	ND	ND
Iron	1900	2190	1240	9170	5580	7910	ND
Lead	5.91	ND	ND	ND	12	ND	ND
Magnesium	27500	18900	36700	17400	12800	20000	ND
Manganese	72.6	425	137	727	1680	626	ND
Mercury	ND	ND	ND	ND	ND	ND	ND
Molybdenum	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	ND	ND
Potassium	5900	3210	5960	3050	2510	2470	ND
Sodium	63000	41200	36100	13600	17100	38400	ND
Tellurium	ND	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND	ND
Tin	ND	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND	ND
Zinc	50.6	19.1	20.9	39.5	19.2	39.4	ND
Aldrin	0.044 U	0.026 U	ND	ND	ND	ND	ND
Alpha-Benzene Hexachloride	ND	0.007 U	ND	ND	ND	ND	ND
Alpha-Endosulfan	ND	ND	ND	ND	ND	ND	ND
Beta-Benzene Hexachloride	ND	ND	ND	ND	ND	ND	ND
Beta-Endosulfan	ND	ND	ND	ND	ND	ND	ND
DDT	ND	ND	ND	ND	0.006 U	ND	ND
DDD	ND	ND	ND	ND	ND	ND	ND
DDE	ND	ND	ND	ND	ND	ND	ND
Delta-benzene Hexachloride	ND	0.011 U	0.007 U	ND	ND	ND	ND
Dieldrin	ND	0.025 U	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	0.039 U	ND	ND	ND
Heptachlor Epoxide	ND	0.013 U	ND	ND	ND	ND	ND
Isodrin	ND	ND	ND	ND	0.019 U	ND	ND
Lindane	ND	0.006 C	ND	ND	ND	ND	ND
2-Hexanone	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	9	ND	ND	ND	22	ND
1,2-Dichloroethenes	ND	ND	ND	ND	ND	34	ND
1,3-Dimethylbenzene	ND	ND	1.1	ND	ND	ND	16
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl) phthalate	ND	ND	ND	ND	ND	ND	ND
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	2.2	ND	ND	ND	7.7
Methyl Isobutyl Ketone	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	1.7	4.7	ND	ND	ND	33
Trichloroethene	ND	ND	ND	ND	1.3	6.6	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND
Xylenes	ND	2.6	4.4	ND	ND	ND	24

**Key:**

All results are in ug/l

ND – Not Detected

U – Unconfirmed Analysis

C – Confirmed Analysis

**TABLE 5.1e (cont.) Summary of Constituents Present in the Groundwater at the Industrial and Sanitary Waste Landfill**

PARAMETER	S2567MW18D 8/19/92	S2567FD18D 8/19/92	S2567MW320 8/19/92	S2567MW32D 8/21/92	B018MW4800 9/21/93	B018MW48D0 9/21/93
Aluminum	187	258	9040	270000	ND	ND
Antimony	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	3.39	ND	ND	ND
Barium	449	464	807	1330	ND	ND
Beryllium	ND	110	ND	28.3	ND	ND
Boron	ND	ND	ND	712	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND
Calcium	670000	760000	270000	*	ND	ND
Chromium	ND	ND	27	119	ND	ND
Cobalt	ND	ND	ND	211	ND	ND
Copper	ND	ND	ND	237	ND	ND
Iron	335	414	18100	36400	ND	ND
Lead	ND	ND	18.2	ND	ND	ND
Magnesium	490000	550000	54200	640000	ND	ND
Manganese	99.7	102	1240	58000	ND	ND
Mercury	ND	ND	ND	0.76	ND	ND
Molybdenum	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	34.6	499	ND	ND
Potassium	74200	75900	22800	48500	ND	ND
Sodium	*	*	48300	*	ND	ND
Tellurium	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND
Tin	ND	ND	ND	76.1	ND	ND
Vanadium	ND	ND	31.2	208	ND	ND
Zinc	1900	ND	89.8	1350	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND
Alpha - Benzene Hexachloride	ND	ND	ND	ND	ND	ND
Alpha - Endosulfan	ND	ND	ND	ND	ND	ND
Beta - Benzene Hexachloride	ND	ND	ND	ND	ND	ND
Beta - Endosulfan	ND	ND	ND	ND	ND	ND
DDT	ND	ND	ND	ND	ND	ND
DDD	ND	ND	ND	ND	ND	ND
DDE	0.005 U	0.005 U	ND	ND	ND	ND
Delta - benzene Hexachloride	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	ND	ND	ND	ND	ND	ND
Isodrin	ND	ND	ND	ND	ND	ND
Lindane	ND	ND	ND	ND	ND	ND
2 - Hexanone	ND	ND	ND	ND	ND	1.1 S
1,1 - Dichloroethane	ND	ND	ND	ND	ND	ND
1,2 - Dichloroethenes	ND	ND	ND	ND	ND	ND
1,3 - Dimethylbenzene	16	13	ND	5.8	ND	1.2
2,4 - Dimethylphenol	14.8	20.5	ND	ND	ND	ND
Acetone	ND	ND	ND	100	> 100	230
Benzene	1.9	1.5	ND	6.9	ND	ND
Bis(2-ethylhexyl) phthalate	ND	ND	ND	ND	ND	ND
Carbon Disulfide	ND	ND	ND	ND	7.3 S	ND
Carbon Tetrachloride	1.1	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	7.2	ND	ND
Methyl Isobutyl Ketone	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	ND
Tetrachloroethane	ND	ND	1.1	ND	ND	ND
Toluene	4.4	3.5	ND	36	ND	1.3
Trichloroethene	ND	ND	1.2	ND	ND	ND
Vinyl Chloride	ND	ND	> 150	ND	ND	ND
Xylenes	ND	ND	ND	38	ND	2 (1)

**Key:**

All results are in ug/l

ND - Not Detected

U - Unconfirmed Analysis

C - Confirmed Analysis

\* - This concentration for calcium is >270000 ug/l; concentrations for sodium are >48300 ug/l

**TABLE 5.2a Summary of Constituents Present in the Groundwater at the Old Landfill above MCLs**

PARAMETER	MCL UG/L	S004MW0200 12/10/91	S004MW0300 12/10/91	S004MW0400 12/4/91	S004MW0400 9/2/92	S004FD0500 12/9/91	S004MW4700 8/21/92
Aluminum	50-200	992	1360	22900	2710	526	44200
Antimony	6	ND	ND	65	ND	ND	ND
Boron	-	ND	ND	ND	ND	ND	367
Calcium	-	130000	60600	172000	69700	102000	26600
Cobalt	-	ND	ND	32.8	ND	ND	ND
Copper	1000	24.2	30.3	41.1	ND	23.1	57.2
Iron	300	3590	3070	51200	5560	2180	39100
Lead	15	21.3	9.12	101	9.65	ND	106
Magnesium	-	36600	9870	18400	13000	13600	6440
Manganese	50	162	74.2	1000	361	193	324
Potassium	-	4860	1690	5310	2700	1510	7690
Sodium	-	47000	89000	27800	70000	13000	180000
Vanadium	-	ND	ND	39.8	ND	ND	34.1
1,3-Dimethylbenzene	-	3.7	ND	ND	ND	ND	14
Acetone	-	ND	ND	ND	ND	ND	>100

**TABLE 5.2a Summary of Constituents Present in the Groundwater at the Old Landfill above MCLs**

PARAMETER	MCL UG/L	S004MW1900 5/26/92	S004FD1900 5/26/92	S004MW19DD 9/10/92	S004MW4200 8/19/92	S004FD4200 8/19/92
Aluminum	50-200	1220	1560	350000	285	322
Antimony	6	ND	ND	217	ND	ND
Beryllium	4	ND	ND	16.2	ND	ND
Calcium	-	86400	89900	*	78200	61100
Chromium	100	ND	ND	448	ND	ND
Cobalt	-	ND	ND	186	ND	ND
Iron	300	3060	3600	342000	2390	2590
Magnesium	-	13900	14300	960000	11600	12000
Manganese	50	252	270	65000	124	129
Molybdenum	-	ND	ND	58.8	ND	ND
Nickel	100	ND	ND	427	ND	ND
Potassium	-	ND	1660	83500	1830	1780
Sodium	-	12800	13900	*	20900	21100
Tellurium	-	ND	ND	211	ND	ND
Thallium	2	ND	ND	497	ND	ND
Tin	-	ND	ND	62.9	ND	ND
Vanadium	-	ND	ND	237	ND	ND
2-Hexanone	-	ND	ND	5.3 R	ND	ND
1,3-Dimethylbenzene	-	ND	ND	ND	ND	1.11
2,4-Dimethylphenol	-	ND	ND	20	ND	ND
Methyl Isobutyl Ketone	-	ND	ND	5.3	ND	ND

**Key:**

All results are in ug/l

ND - Not Detected

U - Unconfirmed Analysis

R - Analysis required for reporting purposes but not certified

\* - This concentration for sodium is > 220000 ug/l; concentrations for calcium is > 270000 ug/l

TABLE 5.2b Summary of Constituents Present in the Groundwater at the New Landfill above MCLs

PARAMETER	MCL UG/L	S001MW1134 12/5/91	S001MW2300 8/19/92	S001MW23D0 8/19/92	S001MW4310 8/19/92	S001MW4410 8/19/92
Aluminum	50-200	22900	17000	10800	1060	1980
Boron	-	ND	ND	ND	535	450
Calcium	-	174000	510000	*	139000	55900
Iron	300	53400	29600	17100	1560	1180
Lead	15	18.6	62.7	30	ND	ND
Magnesium	-	54600	46200	920000	19300	29700
Manganese	50	1700	935	1330	70.3	34.5
Potassium	-	28200	11900	154000	9260	31100
Sodium	-	*	110000	*	120000	62000
Thallium	2	189	ND	ND	ND	ND
Vanadium	-	36.9	ND	ND	ND	ND
1,3-Dimethylbenzene	-	ND	1.4	4.3	ND	ND
Acetone	-	ND	ND	ND	>100	ND

**Key:**

All results are in ug/l

ND - Not Detected

H - Out of control but data accepted due to high recoveries

S - Results based on internal standards

(1) - Results less than CRL but greater than Criteria of Detection (COD)



**TABLE 5.2c Summary of Constituents Present in the Groundwater at the Industrial and Sanitary Waste Landfill above MCLs**

PARAMETER	MCL UG/L	S2567MW080 12/16/91	S2567MW090 12/17/91	S2567MW122 12/6/91	S2567MW124 12/11/91	S2567MW450 8/21/92	S2567MW180 12/17/91
Aluminum	50-200	1730	952	3000	4340	171	2870
Boron	-	ND	ND	ND	ND	276	ND
Calcium	-	143000	82600	88000	123000	79600	115000
Iron	300	2190	1240	9170	5580	132	1600
Lead	15	ND	ND	ND	12	ND	18.3
Magnesium	-	18900	38700	17400	12800	24200	35400
Manganese	50	425	137	727	1680	53.2	258
Potassium	-	3210	5980	3050	2510	6310	4500
Sodium	-	41200	36100	13600	17100	29300	44500
Delta-benzene Hexachloride	-	0.011 U	0.007 U	ND	ND	ND	0.015 C
1,1-Dichloroethane	-	9	ND	ND	ND	ND	ND
1,3-Dimethylbenzene	-	ND	1.1	ND	ND	ND	ND
Acetone	-	ND	ND	ND	ND	ND	>100
Carbon Disulfide	-	ND	ND	ND	ND	7.9 R	ND
Vinyl Chloride	2	ND	ND	ND	ND	ND	17

**TABLE 5.2c Summary of Constituents Present in the Groundwater at the Industrial and Sanitary Waste Landfill above MCLs**

PARAMETER	MCL UG/L	S2567MW180 8/22/92	S2567MW18D 8/19/92	S2567FD18D 8/19/92	S2567MW320 8/19/92	S2567MW32D 8/21/92	S2567MW460 8/22/92
Aluminum	50-200	279	187	256	9040	270000	272
Beryllium	4	ND	ND	110	ND	28.3	ND
Boron	-	471	ND	ND	ND	712	259
Calcium	-	99500	670000	760000	270000	*	74400
Chromium	100	ND	ND	ND	27	119	ND
Cobalt	-	ND	ND	ND	ND	211	ND
Copper	1000	ND	ND	ND	ND	237	ND
Iron	300	148	335	414	18100	36400	235
Lead	15	6.38	ND	ND	18.2	ND	ND
Magnesium	-	33400	490000	550000	54200	640000	20100
Manganese	50	235	99.7	162	1240	58000	50.6
Nickel	100	ND	ND	ND	34.6	499	ND
Potassium	-	11200	74200	75900	22800	48500	3570
Sodium	-	43100	*	*	48300	*	820000
Tin	-	ND	ND	ND	ND	76.1	ND
Vanadium	-	ND	ND	ND	31.2	208	ND
1,3-Dimethylbenzene	-	16	16	13	ND	5.8	ND
2,4-Dimethylphenol	-	14.8	14.8	20.8	ND	ND	ND
Acetone	-	ND	ND	ND	ND	>100	ND
Benzene	5	1.9	1.9	1.5	ND	6.9	ND
Vinyl Chloride	2	ND	ND	ND	>150	ND	ND

**TABLE 5.2c Summary of Constituents Present in the Groundwater at the Industrial and Sanitary Waste Landfill above MCLs**

PARAMETER	MCL UG/L	S2567MW330 8/19/92	S2567FD330 8/19/92	S2567MW8D0 8/22/92	B004MW4700 9/9/93	B018MW4800 9/21/93	B018MW48D 9/21/93
Aluminum	50-200	4400	2730	512	ND	ND	ND
Boron	-	ND	ND	613	ND	ND	ND
Calcium	-	190000	165000	189000	ND	ND	ND
Iron	300	8630	6660	7910	ND	ND	ND
Lead	15	25.8	17.1	ND	ND	ND	ND
Magnesium	-	43300	40400	20000	ND	ND	ND
Manganese	50	418	337	628	ND	ND	ND
Potassium	-	10200	6620	2470	ND	ND	ND
Sodium	-	49800	46800	38400	ND	ND	ND
2-Hexanone	-	ND	ND	ND	ND	ND	1.1 S
1,1-Dichloroethane	-	ND	ND	22	ND	ND	ND
1,2-Dichloroethenes	70-100	ND	ND	34	ND	ND	ND
1,3-Dimethylbenzene	-	4	6.6	ND	16	ND	1.2
Benzene	5	ND	0.93	ND	ND	>100	230
Carbon Disulfide	-	ND	ND	ND	ND	7.3 S	ND
Trichloroethene	5	ND	ND	6.6	ND	ND	ND

**Key:**

- ll results are in ug/l
- ND - Not Detected
- U - Unconfirmed Analysis
- C - Confirmed Analysis
- R - This analysis is required for reporting purposes but not certified
- \* - This concentration for calcium is >270000 ug/l; concentrations for sodium are >48300 ug/l

TABLE 5.2e Summary of Constituents Present in the Groundwater at Area B above MCLs				
PARAMETER	MCL UG/L	A00BMW1123 12/6/91	A00BMW1123 9/3/92	S2567MW4500 8/21/92
Aluminum	50 – 200 *	6450	65100	171
Antimony	6	73.2	ND	ND
Barium	2000	ND	ND	177
Boron	–	ND	305	276
Calcium	–	162000	210000	79600
Chromium	100	71	139	ND
Cobalt	–	ND	35.9	ND
Iron	300	17600	84000	132
Lead	15	11.6	95.4	ND
Magnesium	–	21000	40600	24200
Manganese	50	4740	5120	53.2
Potassium	–	4310	26600	6310
Sodium	–	10100	17400	29300
Vanadium	–	ND	85.4	ND
Zinc	5000*	ND	ND	77
DDT	–	0.008 C	ND	ND
1,3-Dimethylbenzene	–	ND	2.2	ND
Carbon Disulfide	–	ND	ND	7.9 R
Phenol	–	ND	17	ND

**Key:**

All results are in ug/l

\* – Secondary Maximum Contaminant Levels

ND – Not Detected

C – Confirmed Analysis

**TABLE 5.2f Summary of Constituents Present in the Groundwater at Area C above MCLs**

PARAMETER	MCL UG/L	A00CMW1009 12/5/91	A00CMW1009 9/2/92	
Aluminum	50–200 *	24300	15900	
Boron	–	ND	389	
Cadmium	5	ND	ND	
Calcium	–	80400	33600	
Iron	300	37800	16400	
Lead	15	25.1	19.3	
Magnesium	–	22700	15500	
Manganese	50	764	288	
Potassium	–	11600	8700	
Sodium	–	55000	94000	
Vanadium	–	42.2	ND	
1,3–Dimethylbenzene	–	ND	1.3	
Chloromethane	–	4.4	ND	

**Key:**

All results are in ug/l

ND – Not Detected

U – Unconfirmed Analysis

C – Confirmed Analysis



TABLE 5.3a Summary of Constituents Present in Groundwater above Background (MW07) at the Old Landfill

PARAMETER	BACKGROUNDFACLMW0700 UG/L	BACKGROUNDS2567MW070 UG/L	BACKGROUNDAVERAGE UG/L	S004MW0400 9/2/92	S004FD0500 12/9/91	S004MW1900 5/26/92	S004FD1900 5/26/92	S004MW0200 12/10/91
Arsenic	ND	ND	ND	ND	ND	ND	ND	3.89
Calcium	89300	82000	86650	89700	102500	82400	89300	130000
Iron	4250	1900	3075	5560	2180	3060	3500	3590
Lead	13.2	5.91	9.555	9.65	ND	ND	7.58	21.3
Magnesium	28100	27500	27800	13000	13600	13900	14300	36600
Manganese	96.7	72.6	84.65	381	193	282	279	162
Mercury	ND	ND	ND	ND	0.116	ND	ND	ND
Sodium	57000	63000	60000	70000	13000	12800	13300	47000

TABLE 5.3a (cont.) Summary of Constituents Present in Groundwater above Background (MW07) at the Old Landfill

PARAMETER	BACKGROUNDFACLMW0700 UG/L	BACKGROUNDS2567MW070 UG/L	BACKGROUNDAVERAGE UG/L	S004MW1900 9/10/92	S004MW4200 8/19/92	S004FD4200 8/19/92	S004MW4700 8/21/92	S004MW0400 12/4/91
Aluminum	4520	3310	3915	35000	285	322	44200	22000
Antimony	ND	ND	ND	217	ND	ND	ND	63
Arsenic	ND	ND	ND	ND	ND	ND	ND	10.8
Barium	221	211	216	1870	72.6	76.2	194	300
Beryllium	1.11	ND	0.555	18.2	ND	ND	1.1	1.68
Boron	ND	ND	ND	ND	ND	ND	367	ND
Calcium	89300	82000	85650	84300	78200	81100	26600	172000
Chromium	ND	ND	ND	448	ND	ND	41.6	32.8
Cobalt	ND	ND	ND	186	ND	ND	ND	32.6
Copper	ND	100	50	257	ND	ND	57.2	41.1
Iron	4250	1900	3075	342000	2380	2590	39100	51200
Lead	13.2	5.91	9.555	ND	ND	ND	109	101
Magnesium	28100	27500	27800	980000	11600	12000	8440	18400
Manganese	96.7	72.6	84.65	65000	124	129	924	1000
Mercury	ND	ND	ND	1.54	ND	ND	0.101	ND
Molybdenum	ND	ND	ND	58.8	ND	ND	ND	ND
Nickel	ND	ND	ND	427	ND	ND	59.3	ND
Potassium	7080	5900	6490	63500	1830	1780	7630	5310
Sodium	57000	63000	60000	70000	20300	21100	180000	27800
Tellurium	ND	ND	ND	211	ND	ND	ND	ND
Thallium	ND	ND	ND	437	ND	ND	ND	ND
Tin	ND	ND	ND	52.9	ND	ND	ND	ND
Vanadium	ND	ND	ND	297	ND	ND	34.1	39.8
Zinc	138	50.6	94.3	1140	ND	ND	154	139

Key:

All results are in ug/l  
ND - Not Detected

TABLE 5.3b Summary of Constituents Present in Groundwater above Background (MW07) at the New Landfill

PARAMETER	BACKGROUND FACLMW0700 UG/L	BACKGROUND S2567MW070 UG/L	BACKGROUND AVERAGE UG/L	S001MW1134 12/5/91	S001MW2300 8/19/92	S001MW2300 8/19/92	S001MW2300 8/19/92	S001MW4310 8/19/92	S001MW4410 8/19/92
Aluminum	4520	3310	3915	23900	17000	10500	10500	1060	1980
Arsenic	ND	ND	ND	8.78	5.93 H	ND	ND	ND	ND
Barium	221	211	216	183	173	570	570	29.8	27.4
Beryllium	1.11	ND	0.555	1.73	ND	3.1	3.1	ND	ND
Boron	ND	ND	ND	ND	ND	ND	ND	835	450
Calcium	89300	82000	85650	174000	510000	*	*	139000	55900
Chromium	ND	ND	ND	47.1	ND	ND	ND	ND	ND
Iron	4250	1900	3075	53400	29600	17100	17100	1560	1180
Lead	13.2	5.91	9.555	18.6	82.7	30	30	ND	ND
Magnesium	28100	27500	27800	84600	46200	920000	920000	19300	29700
Manganese	96.7	72.6	84.65	1700	935	1330	1330	70.3	34.5
Mercury	ND	ND	ND	ND	ND	0.105	0.105	ND	ND
Nickel	ND	ND	ND	49.7	41.4	ND	ND	ND	ND
Potassium	7080	5900	6490	28200	11900	184000	184000	9260	31100
Sodium	57000	63000	60000	*	110000	*	*	120000	62000
Thallium	ND	ND	ND	189	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	86.9	ND	ND	ND	ND	ND
Zinc	138	50.6	94.3	111	56.1	44.2	44.2	30.9	40.7

## Key:

All results are in ug/l

ND – Not Detected

TABLE 5.3c Summary of Constituents Present in Groundwater above Background (MW07) at the Industrial and Sanitary Waste Landfill

PARAMETER	BACKGROUND FACLMW0700 UG/L	BACKGROUND S2567MW070 UG/L	BACKGROUND AVERAGE UG/L	S2567MW080 12/16/91	S2567MW090 12/17/91	S2567MW122 12/6/91	S2567MW124 12/11/91
Aluminum	4520	3310	3915	1730	952	3000	4340
Barium	221	211	216	184	307	350	113
Calcium	89300	82000	85650	143000	82600	88000	123000
Chromium	ND	ND	ND	36.4	ND	ND	ND
Iron	4250	1900	3075	2190	1240	9170	5580
Lead	13.2	5.91	9.555	ND	ND	ND	12
Magnesium	28100	27500	27800	18900	36700	17400	12800
Manganese	96.7	72.6	84.65	425	137	727	1680
Lindane	ND	ND	ND	0.006 C	ND	ND	ND

TABLE 5.3c (cont.) Summary of Constituents Present in Groundwater above Background (MW07) at the Industrial and Sanitary Waste Landfill

PARAMETER	BACKGROUND FACLMW0700 UG/L	BACKGROUND S2567MW070 UG/L	BACKGROUND AVERAGE UG/L	S2567MW180 12/17/91	S2567MW180 8/22/92	S2567MW18D 8/19/92	S2567MW320 8/19/92
Aluminum	4520	3310	3915	2870	279	187	9040
Arsenic	ND	ND	ND	ND	ND	ND	3.39
Barium	221	211	216	235	213	449	597
Boron	ND	ND	ND	ND	471	ND	ND
Calcium	89300	82000	85650	115000	99500	670000	270000
Chromium	ND	ND	ND	ND	ND	ND	27
Iron	4250	1900	3075	1600	146	335	18100
Lead	13.2	5.91	9.555	15.3	6.38	ND	18.2
Magnesium	28100	27500	27800	35400	33400	490000	54200
Manganese	96.7	72.6	84.65	256	235	99.7	1240
Nickel	ND	ND	ND	ND	ND	ND	34.6
Potassium	7080	5900	6490	4500	11200	74200	22800
Vanadium	ND	ND	ND	ND	ND	ND	31.2
Zinc	138	50.6	94.3	34.9	110	1900	89.8
Delta - benzene Hexachloride	ND	ND	ND	0.015 C	ND	ND	ND

Key:

All results are in ug/l

ND -- Not Detected

PARAMETER	BACKGROUNDFACLMW0700UG/L	BACKGROUNDS2567MW070UG/L	BACKGROUNDAVERAGEUG/L	S2567MW32D8/21/92	S2567MW3308/19/92	S2567FD3308/19/92	S2567MW4508/21/92
Aluminum	4520	3310	3915	270000	4400	2730	171
Barium	221	211	216	1330	229	214	177
Beryllium	1.11	ND	0.555	28.3	2.36	ND	ND
Boron	ND	ND	ND	712	ND	ND	276
Calcium	89300	82000	85650	*	190000	165000	79600
Chromium	ND	ND	ND	119	ND	ND	ND
Cobalt	ND	ND	ND	211	ND	ND	ND
Copper	ND	100	50	237	ND	ND	ND
Iron	4250	1900	3075	36400	8630	6660	132
Lead	13.2	5.91	9.555	ND	25.8	17.1	ND
Magnesium	28100	27500	27800	640000	43300	40400	24200
Manganese	96.7	72.6	84.65	58000	418	337	53.2
Mercury	ND	ND	ND	0.76	ND	ND	ND
Molybdenum	ND	ND	ND	499	ND	ND	ND
Nickel	ND	ND	ND	48500	10200	6620	6310
Potassium	7080	5900	6490	76.1	ND	ND	ND
Tin	ND	ND	ND	208	ND	ND	ND
Vanadium	ND	ND	ND	1350	63.9	28.8	77
Zinc	138	50.6	94.3				

PARAMETER	BACKGROUNDFACLMW0700UG/L	BACKGROUNDS2567MW070UG/L	BACKGROUNDAVERAGEUG/L	S2567MW4608/22/92	S2567MW8D08/22/92	S2567FD18D8/19/92
Barium	221	211	216	207	174	464
Beryllium	1.11	ND	0.555	ND	ND	110
Boron	ND	ND	ND	289	613	ND
Calcium	89300	82000	85650	74400	169000	760000
Iron	4250	1900	3075	235	7910	414
Magnesium	28100	27500	27800	20100	20000	550000
Manganese	96.7	72.6	84.65	50.6	626	102
Potassium	7080	5900	6490	3570	2470	75900
Sodium	57000	63000	60000	820000	38400	*
Zinc	138	50.6	94.3	134	39.4	ND

Key:  
 All results are in ug/l  
 ND – Not Detected

TABLE 5.3d Summary of Constituents Present in Groundwater above Background (MW07) at the Industrial Waste Lagoons

PARAMETER	BACKGROUNDFACLMW0700UG/L	BACKGROUNDS2567MW070UG/L	BACKGROUNDAVERAGEUG/L	S003MW060012/11/91	S003MW105111/24/91	S003MW10519/1/92	S003MW105212/6/91	S003FD105212/6/91
Aluminum	4520	3310	3915	2470	3500	ND	34400	ND
Barium	221	211	216	99.9	161	145	827	ND
Beryllium	1.11	ND	0.555	ND	ND	ND	2.86	ND
Boron	ND	ND	ND	ND	ND	388	ND	ND
Cadmium	ND	ND	ND	ND	7.22	ND	343	ND
Calcium	89300	82000	85650	153000	118000	95300	240000	ND
Chromium	ND	ND	ND	28.7	18.1	ND	173	ND
Cobalt	ND	ND	ND	ND	ND	ND	28	ND
Copper	ND	100	50	ND	ND	ND	158	ND
Iron	4250	1900	3075	3200	5940	624	152000	ND
Lead	13.2	5.91	9.555	ND	5.55	ND	27.1	32.1
Magnesium	28100	27500	27800	54200	31200	25800	55300	ND
Manganese	96.7	72.6	84.65	306	342	150	6670	ND
Nickel	ND	ND	ND	ND	ND	ND	111	ND
Potassium	7080	5900	6490	6160	4940	3520	12000	ND
Vanadium	ND	ND	ND	ND	ND	ND	53.8	ND
Zinc	138	50.6	94.3	29.5	36.2	ND	388	ND
Alpha - Benzene Hexachloride	ND	ND	ND	0.009 U	0.004 U	ND	0.003 C	0.008 U
Lindane	ND	ND	ND	0.003 C	ND	ND	0.008 U	0.014 U

## Key:

All results are in ug/l

ND - Not Detected

C - Confirmed Analysis

TABLE 5.3d (cont.) Summary of Constituents Present in Groundwater above Background (MW07) at the Industrial waste Lagoons

PARAMETER	BACKGROUND FACLMW0700 UG/L	BACKGROUND S2567MW070 UG/L	BACKGROUND AVERAGE UG/L	S003MW40D0 8/21/92	S003FD40D0 8/21/92	S003MW4100 8/19/92	S003MW6D00 8/21/92
Aluminum	4520	3310	3915	2520	1620	605	87600
Barium	221	211	216	106	105	38.5	911
Beryllium	1.11	ND	0.555	ND	ND	ND	36.5
Boron	ND	ND	ND	1110	1180	408	1930
Calcium	89300	82000	85650	131000	115000	88200	*
Chromium	ND	ND	ND	ND	ND	ND	273
Cobalt	ND	ND	ND	ND	ND	ND	26.1
Copper	ND	100	50	ND	ND	ND	77.8
Iron	4250	1900	3075	4080	2580	793	111000
Lead	13.2	5.91	9.555	ND	ND	ND	470
Magnesium	28100	27500	27800	43000	46800	9930	750000
Manganese	96.7	72.6	84.65	292	201	1080	17000
Mercury	ND	ND	ND	ND	ND	ND	0.174
Nickel	ND	ND	ND	ND	ND	ND	152
Potassium	7080	5900	6490	10900	12000	2530	122000
Sodium	57000	63000	60000	190000	220000	15800	*
Tin	ND	ND	ND	ND	ND	ND	94.9
Vanadium	ND	ND	ND	ND	ND	ND	523
Zinc	138	50.6	94.3	58.3	72.3	43.1	1850

Key:

All results are in ug/l

ND – Not Detected



TABLE 5.3d (cont.) Summary of Constituents Present in Groundwater above Background (MW07) at the Industrial Waste Lagoons

PARAMETER	BACKGROUND FACLMW0700 UG/L	BACKGROUND S2567MW070 UG/L	BACKGROUND AVERAGE UG/L	S003MW1600 9/2/92	S003MW3900 8/21/92	S003MW4000 8/20/92	S003FD4000 8/20/92
Aluminum	4520	3310	3915	262	94800	666	746
Arsenic	ND	ND	ND	ND	25	ND	ND
Barium	221	211	216	74	849	266	205
Beryllium	1.11	ND	0.555	ND	36.5	ND	ND
Boron	ND	ND	ND	271	2420	557	393
Calcium	89300	82000	85650	107000	*	115000	93200
Chromium	ND	ND	ND	ND	210	ND	ND
Cobalt	ND	ND	ND	ND	69	ND	ND
Copper	ND	100	50	ND	66.2	ND	ND
Iron	4250	1900	3075	1570	135000	1680	1260
Lead	13.2	5.91	9.555	ND	180	ND	ND
Magnesium	28100	27500	27800	32400	830000	37500	28900
Manganese	96.7	72.6	84.65	141	14000	157	142
Mercury	ND	ND	ND	ND	0.299	ND	ND
Nickel	ND	ND	ND	ND	169	ND	ND
Potassium	7080	5900	6490	4010	125000	5680	5410
Sodium	57000	63000	60000	40800	*	48900	37800
Tin	ND	ND	ND	ND	102	ND	ND
Vanadium	ND	ND	ND	ND	523	ND	ND
Zinc	138	50.6	94.3	ND	1470	34.9	27

Key:

All results are in ug/l

ND -- Not Detected

TABLE 5.3d (cont.) Summary of Constituents Present in Groundwater above Background (MW07) at the Industrial Waste Lagoons

PARAMETER	BACKGROUND FACLMW0700 UG/L	BACKGROUND S2567MW070 UG/L	BACKGROUND AVERAGE UG/L	S003MW1052 9/2/92	S003FD1052 9/2/92	S003MW1053 11/24/91	S003MW1600 12/10/91
Aluminum	4520	3310	3915	3840	9150	143	2390
Arsenic	ND	ND	ND	2.9	3.89	ND	ND
Barium	221	211	216	83.7	143	168	262
Boron	ND	ND	ND	257	274	ND	ND
Cadmium	ND	ND	ND	147	291	ND	ND
Calcium	89300	82000	85650	153000	160000	93900	141000
Chromium	ND	ND	ND	41.8	119	ND	ND
Iron	4250	1900	3075	18600	47100	1020	19300
Lead	13.2	5.91	9.555	6.71	14.6	ND	9.32
Magnesium	28100	27500	27800	30800	32700	36200	35000
Manganese	96.7	72.6	84.65	1610	4000	42.3	377
Nickel	ND	ND	ND	39.7	79.6	ND	ND
Thallium	ND	ND	ND	ND	ND	ND	196
Zinc	138	50.6	94.3	110	161	ND	24.2
Alpha-Endosulfan	0.005 U	ND	ND	ND	ND	ND	>0.5

## Key:

All results are in ug/l

ND - Not Detected



TABLE 5.3e Summary of Constituents Present in Groundwater at Area B above Background

PARAMETER	BACKGROUNDFACLMW0700UG/L	BACKGROUNDS2567MW070UG/L	BACKGROUNDAVERAGEUG/L	A00BMW112312/6/91	A00BMW11239/3/92
Aluminum	4520	3310	3915	6450	65100
Antimony	ND	ND	ND	73.2	ND
Arsenic	ND	ND	ND	ND	10.9
Barium	221	211	216	62.4	307
Beryllium	1.11	ND	0.555	ND	3.02
Boron	ND	ND	ND	ND	305
Calcium	89300	82000	85650	162000	210000
Chromium	ND	ND	ND	71	139
Cobalt	ND	ND	ND	ND	35.9
Copper	ND	100	50	ND	55.6
Iron	4250	1900	3075	17600	84000
Lead	13.2	5.91	9.555	11.6	95.4
Magnesium	28100	27500	27800	21000	40600
Manganese	96.7	72.6	84.65	4740	5120
Nickel	ND	ND	ND	ND	97.9
Potassium	7080	5900	6490	4310	26600
Vanadium	ND	ND	ND	ND	85.4
Zinc	138	50.6	94.3	48.4	244

**Key:**

All results are in ug/l

ND – Not Detected

TABLE 5.3f Summary of Constituents Present in Groundwater at Area C above Background

PARAMETER	BACKGROUND FACLMW0700 UG/L	BACKGROUND S2567MW070 UG/L	BACKGROUND AVERAGE UG/L	A00CMW1009 12/5/91	A00CMW1009 9/2/92
Aluminum	4520	3310	3915	24300	15900
Arsenic	ND	ND	ND	ND	3.32
Beryllium	1.11	ND	0.555	1.55	ND
Boron	ND	ND	ND	ND	389
Chromium	ND	ND	ND	34.4	42.5
Iron	4250	1900	3075	37800	16400
Lead	13.2	5.91	9.555	25.1	19.3
Manganese	96.7	72.6	84.65	764	288
Nickel	ND	ND	ND	38.3	ND
Potassium	7080	5900	6490	11600	8700
Sodium	57000	63000	60000	55000	94000
Vanadium	ND	ND	ND	42.2	ND
Zinc	138	50.6	94.3	103	66.7

**Key:**

All results are in ug/l

ND – Not Detected

**TABLE 5.4**  
**Summary of Inorganics Present in Background (MW07) Above MCLs**

		4-DEC-91	12-DEC-91	BACKGROUND
PARAMETER	MCL ( $\mu\text{g/l}$ )	FACLMW0700	S2567MW070	AVERAGE
Aluminum	50-200	4520	3310	3915
Calcium	none	89300	82000	85650
Iron	300	4250	1900	3075
Magnesium	none	28100	27500	27800
Manganese	200	96.7	72.6	84.65
Potassium	none	7080	5900	6490
Sodium	none	57000	63000	60000

Key:  
All results are in  $\mu\text{g/l}$ .

**TABLE 5.5**  
**Summary of Organics and Pesticides Present**  
**in Background (MW07) Above MCLs**

PARAMETER	MCL (µg/l)	4-DEC-91	
		FACLMW0700	S2567MW070
1,2-Dichloroethenes	70	ND	ND
2,4-Dimethyl Phenol	none	ND	ND
2-Hexanone	none	ND	ND
Acetone	none	ND	ND
Benzene	5	ND	ND
Bis(2-ethylhexyl)phthalate	none	ND	ND
Carbon Disulfide	none	ND	ND
Carbon Tetrachloride	5	ND	ND
Chloromethane	none	ND	ND
Ethylbenzene	700	ND	ND
Methyl Isobutyl Ketone	none	ND	ND
Phenol	none	ND	ND
Toluene	1000	ND	ND
Trichloroethene	5	ND	ND
Tetrachloroethene	5	ND	ND
Vinyl Chloride	2	ND	ND
Xylene	10000	ND	ND
Aldrin	none	ND	ND
Alpha-Benzene Hexachloride	none	ND	ND
Alpha-Endosulfan	none	0.005 U	ND
Beta-Endosulfan	none	ND	ND
Beta-Benzene Hexachloride	none	ND	ND
DDE	none	ND	ND
DDT	none	0.026	ND
Delta-Benzene Hexachloride	none	ND	ND
Dieldrin	none	ND	ND
Endrin	2	ND	ND
Heptachlor	0.4	0.25 U	ND
Heptachlor Epoxide	0.2	ND	ND
Lindane	0.2	ND	ND
Isodrin	none	ND	ND

Key:  
All results are in µg/l  
ND = Not Detected

TABLE 5.6

## Summary of Inorganics Present above MCLs and/or Background (MW07) at the Old Landfill

PARAMETER	MCL ( $\mu\text{g/l}$ )	BACKGROUND $\mu\text{g/l}$	10-DEC-91 S004 MW0200	10-DEC-91 S004 MW0300	4-DEC-91 S004 MW0400	2-SEPT-92 S004 MW0400	26-MAY-92 S004 MW1900	10-SEPT-92 S004 MW19DD	19-AUG-92 S004 MW4200	21-AUG-92 S004 MW4700
Aluminum	50-200	3915	992	1360	22900	2710	1220	350000	285	44200
Antimony	6	ND	ND	ND	63	ND	ND	217	ND	ND
Arsenic	50	ND	3.89	ND	10.8	ND	ND	ND	ND	ND
Barium	2000	216	78.7	69.3	300	189	53.9	1870	72.6	194
Beryllium	4	0.555	ND	ND	1.66	ND	ND	18.2	ND	1.1
Calcium	none	85650	130000	60800	172000	89700	86400	*	78200	26600
Chromium	100	ND	ND	34.8	32.8	ND	ND	448	ND	41.6
Cobalt	none	ND	ND	ND	32.6	ND	ND	186	ND	ND
Copper	1000	50	24.2	30.3	41.1	ND	ND	257	ND	57.2
Iron	300	3075	3590	3070	51200	5560	3060	342000	2380	39100
Lead	15	9.5	21.3	9.12	101	9.65	ND	ND	ND	106
Manganese	50	84.6	162	74.2	1000	361	252	65000	124	324
Magnesium	none	27800	36600	9870	18400	13000	13900	980000	11600	8440
Molybdenum	none	ND	ND	ND	ND	ND	ND	58.5	ND	ND
Mercury	2	ND	ND	0.127	ND	ND	ND	1.54	ND	0.101
Nickel	100	ND	ND	55.6	ND	ND	ND	427	ND	59.3
Potassium	none	6490	4860	1690	5310	2700	ND	83500	1830	7630
Sodium	none	60000	47000	89000	27800	70000	12800	*	20300	180000
Vanadium	none	ND	ND	ND	39.8	ND	ND	237	ND	34.1
Tellurium	none	ND	ND	ND	ND	ND	ND	211	ND	ND

**TABLE 5.6**  
**Summary of Inorganics Present above MCLs and/or Background (MW07) at the Old Landfill**

		BACKGROUND	10-DEC-91	10-DEC-91	4-DEC-91	2-SEPT-92	26-MAY-92	10-SEPT-92	19-AUG-92	21-AUG-92
PARAMETER	MCL ( $\mu\text{g/l}$ )	$\mu\text{g/l}$	S004 MW0200	S004 MW0300	S004 MW0400	S004 MW0400	S004 MW1900	S004 MW19DD	S004 MW4200	S004 MW4700
Tin	none	ND	ND	ND	ND	ND	ND	62.9	ND	ND
Thallium	2	ND	ND	ND	ND	ND	ND	437	ND	ND
Zinc	5000	94.3	ND	32.3	119	35.1	29.2	1140	ND	154

**Key:**

All results are in  $\mu\text{g/l}$

ND Not Detected

- This concentration for sodium is  $> 180,000 \mu\text{g/l}$ ; calcium is  $> 172,000 \mu\text{g/l}$ .

**TABLE 5.7**  
**Summary of Organics Present above MCLs at the Old Landfill**

PARAMETER	MCL (µg/l)	10-DEC-91	10-DEC-91	4-DEC-91	2-SEPT-92	26-MAY-92	10-SEPT-92	19-AUG-92	21-AUG-92
		S004 MW0200	S004 MW0300	S004 MW0400	S004 MW0400	S004 MW1900	S004 MW19DD	S004 MW4200	S004 MW4700
1,3-Dimethylbenzene	none	13.7	ND	ND	ND	ND	ND	1.11	14
2,4-Dimethyl Phenol	none	ND	ND	ND	ND	ND	20	ND	ND
2-Hexanone	none	ND	ND	ND	ND	ND	5.3 R	ND	ND
Methyl Isobutyl Ketone	none	ND	ND	ND	ND	ND	5.3	ND	ND

**Key:**

All results are in µg/l

ND = Not detected

R - Analysis required for reporting purposes but not certified

TABLE 5.8

## Summary of Inorganics Present above MCLs and/or Background (MW07) at the New Landfill

PARAMETER	MCL ( $\mu\text{g/l}$ )	BACKGROUND $\mu\text{g/l}$	5-DEC-91 S001MW1134	19-AUG-92 S001MW2300	19-AUG-92 S001MW23D0	19-AUG-92 S001MW43I0	19-AUG-92 S001MW44I0
Aluminum	50-200	3915	22900	17000	10800	1060	1980
Arsenic	50	ND	8.78	5.93	ND	ND	ND
Beryllium	4	0.555	1.73	ND	3.1	ND	ND
Calcium	none	85650	174000	510000	*	139000	55900
Chromium	100	ND	47.1	ND	ND	ND	ND
Iron	300	3075	53400	29600	17100	1560	1180
Lead	15	9.5	18.6	62.7	30	ND	ND
Magnesium	none	27800	54600	46200	920000	70.3	29700
Manganese	50	84.6	1700	935	1330	19300	34.5
Molybdenum	none	ND	ND	ND	ND	ND	ND
Mercury	2	ND	ND	ND	0.105	ND	ND
Nickel	100	ND	49.7	41.4	ND	ND	ND
Potassium	none	6490	28200	11900	154000	9260	31100
Sodium	none	60000	*	110000	*	120000	62000
Vanadium	none	ND	36.9	ND	ND	ND	ND
Thallium	2	ND	189	ND	ND	ND	ND
Zinc	5000	94.3	111	56.1	44.2	30.9	40.7

## Key:

All results are in  $\mu\text{g/l}$ 

ND = Not Detected

\* = This concentration for calcium is  $> 510,000 \mu\text{g/l}$ ; concentration for sodium is  $> 110,000 \mu\text{g/l}$ .



**TABLE 5.9**  
**Summary of Organics Present above MCLs at the New Landfill**

	MCL	S001MW1134	S001MW2300	S001MW23D0	S001MW43I0	S001MW44I0
PARAMETER	$\mu\text{G/L}$	12/5/91	8/19/92	8/19/92	8/19/92	8/19/92
Acetone	none	ND	ND	ND	> 100	ND

Key:

All results are in  $\mu\text{g/l}$

ND = Not detected

U = Unconfirmed analysis

C = Confirmed analysis

**TABLE 5.10**  
**Summary of Inorganics Present above MCLs and/or Background (MW07) at the Industrial and Sanitary Waste Landfill**

PARAMETER	MCL (µg/l)	BACKGROUND µg/l	16-DEC-91 S2567 MW080	17-DEC-91 S2567 MW090	6-DEC-91 S2567 MW122	11-DEC-91 S2567 MW124	17-DEC-91 S2567 MW180	22-AUG-92 S2567 MW180	19-AUG-92 S2567 MW18D	19-AUG-92 S2567 MW320	21-AUG-92 S2567 MW32D	19-AUG-92 S2567 MW330	21-AUG-92 S2567 MW450	22-AUG-92 S2567 MW460	22-AUG-92 S2567 MW8D0
Aluminum	50-200	3915	1730	952	3000	4340	2870	279	187	9040	270000	4400	171	272	512
Arsenic	50	ND	ND	ND	ND	ND	ND	ND	ND	3.39	ND	ND	ND	ND	ND
Barium	2000	216	184	307	350	113	235	213	449	807	1330	229	177	207	174
Beryllium	4	0.555	ND	ND	ND	ND	ND	ND	ND	ND	28.3	2.36	ND	ND	ND
Boron	none	ND	ND	ND	ND	ND	ND	471	ND	ND	712	ND	276	259	613
Calcium	none	85650	143000	82600	88000	123000	115000	99300	670000	270000	*	190000	79600	74400	169000
Chromium	100	ND	36.4	ND	ND	ND	ND	ND	ND	27	119	ND	ND	ND	ND
Copper	1000	50	ND	ND	ND	ND	ND	ND	ND	ND	237	ND	ND	ND	ND
Iron	300	3075	2190	1240	9170	5580	1600	146	335	18100	36400	8630	132	235	7910
Lead	15	9.5	ND	ND	ND	12	15.3	6.38	ND	18.2	ND	25.8	ND	ND	ND
Manganese	50	84.6	425	137	727	1680	256	235	99.7	1240	58000	418	53.2	50.6	626
Magnesium	none	27800	18900	36700	17400	12800	35400	33400	490000	54200	640000	43300	24200	20100	20000
Mercury	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.76	ND	ND	ND	ND
Nickel	100	ND	ND	ND	ND	ND	ND	ND	ND	34.6	499	ND	ND	ND	ND
Potassium	none	6490	3210	5960	3050	2510	4500	11200	74200	22800	48300	10200	6310	3570	2470
Sodium	none	60000	41200	36100	13600	17100	44500	43100	*	48300	*	49800	29300	820000	38400
Vanadium	none	ND	ND	ND	ND	ND	ND	ND	ND	31.2	208	ND	ND	ND	ND
Tin	none	ND	ND	ND	ND	ND	ND	ND	ND	ND	76.1	ND	ND	ND	ND
Zinc	5000	94.3	19.1	20.9	39.5	19.2	34.9	110	1900	89.8	1350	63.9	77	134	39.4

**Key:**

All results are in µg/l

ND = Analyte not detected

\* = This concentration for sodium is > 820,000 µg/l.

TABLE 5.11 Summary of Organics Present above MCLs at the Industrial and Sanitary Waste Landfill

PARAMETER	MCL (ug/l)	16-DEC-91 S2567MW080	17-DEC-91 S2567MW090	6-DEC-91 S2567MW122	11-DEC-91 S2567MW124	17-DEC-91 S2567MW180	22-AUG-92 S2567MW180	19-AUG-92 S2567MW18D	9-SEPT-93 B004MW47B0
1,1-Dichloroethane	none	9	ND	ND	ND	ND	ND	ND	ND
1,3-Dimethyl Benzene	none	ND	1.1	ND	ND	ND	16	16	16
2,4-Dimethyl Phenol	none	ND	ND	ND	ND	ND	14.8	14.8	ND
Acetone	none	ND	ND	ND	ND	>100	ND	ND	ND
Vinyl Chloride	2	ND	ND	ND	ND	17	ND	ND	ND

**Key:**

All results are in ug/l

ND – Not Detected

TABLE 5.11 (cont.) Summary of Organics Present above MCLs at the Industrial and Sanitary Waste Landfill

PARAMETER	MCL (ug/l)	19-AUG-92 S2567MW320	21-AUG-92 S2567MW32D	19-AUG-92 S2567MW330	21-AUG-92 S2567MW450	22-AUG-92 S2567MW460	22-AUG-92 S2567MW8DQ	22-AUG-92 B018MW4800	22-AUG-92 B018MW48DQ
1,1-Dichloroethane	none	ND	ND	ND	ND	ND	22	ND	ND
1,3-Dimethyl Benzene	none	ND	5.8	4	ND	ND	ND	ND	1.2
Acetone	none	ND	>100	ND	ND	ND	ND	> 100	1.1 S
Benzene	5	ND	6.9	ND	ND	ND	ND	ND	230
Bis(2-ethylhexyl)phthalate	none	ND	ND	ND	7.9 R	ND	ND	ND	ND
Toluene	1000	ND	36	2.7	ND	ND	6.6	7.3 S	ND
Vinyl Chloride	2	>150	ND	ND	ND	ND	ND	ND	ND

**Key:**

All results are in ug/l

ND – Not Detected

R – Analysis required for reporting purposes but not certified

TABLE 5.12 Summary of Pesticides Present Above MCLs and/or Background at the Industrial and Sanitary Waste Landfill

PARAMETER	MCL UG/L	BACKGROUND ug/l	S2567MW080 12/16/91	S2567MW090 12/17/91	S2567MW122 12/6/91	S2567MW124 12/11/91	S2567MW180 12/17/91	S2567MW180 8/22/92
Delta – benzene Hexachloride	–	ND	0.011 U	0.007 U	ND	ND	0.015 C	ND
Lindane	0.2	ND	0.008 C	ND	ND	ND	ND	ND

**Key:**

All results are in ug/l

ND – Not Detected

U – Unconfirmed Analysis

C – Confirmed Analysis

TABLE 5.13 Summary of Inorganics Present Above MCLs and/or Background at the Industrial Waste Lagoons

PARAMETER	MCL (ug/l)	BACKGROUN Average ug/l	6-DEC-91 S003MW1052	2-SEPT-92 S003MW1052	20-AUG-92 S003MW4000	21-AUG-92 S003MW40Dd	11-DEC-91 S003MW0600	24-NOV-91 S003MW1051	1-SEPT-92 S003MW1051
Aluminum	50-200	3915	34400	3840	666	2520	2470	3500	ND
Arsenic	50	ND	ND	2.9	ND	ND	ND	ND	ND
Barium	2000	216	327	83.7	266	106	99.9	161	ND
Beryllium	4	0.555	2.86	ND	ND	ND	ND	ND	145
Boron	none	ND	ND	257	557	1110	ND	ND	ND
Cadmium	5	ND	343	147	ND	ND	ND	ND	388
Calcium	none	85650	240000	153000	115000	131000	165000	7.22	ND
Chromium	100	ND	173	41.8	ND	ND	28.7	118000	95300
Cobalt	none	ND	28	ND	ND	ND	ND	18.1	ND
Copper	1000	50	156	ND	ND	ND	ND	ND	ND
Iron	300	3075	152000	18600	1680	4080	3200	8940	ND
Lead	15	9.5	27.1	6.71	ND	ND	ND	5.55	624
Manganese	50	84.6	6670	1610	157	292	306	342	ND
Magnesium	none	27800	55300	30800	37500	43000	54200	31200	150
Nickel	100	ND	111	39.7	ND	ND	ND	ND	29600
Potassium	none	6490	12000	3610	5680	10900	6160	ND	ND
Sodium	none	60000	40100	31200	48900	190000	48900	4940	3520
Vanadium	none	ND	53.8	ND	ND	ND	ND	23200	21800
Zinc	5000	94.3	386	110	34.9	58.3	29.5	36.2	ND

Key:

All results are in ug/l

ND - Not Detected

TABLE 5.13 (cont.) Summary of Inorganics Present Above MCLs and/or Background at the Industrial Waste Lagoons

PARAMETER	MCL (ug/l)	BACKGROUN Average ug/l	24-NOV-91 S003MW1053	10-DEC-91 S003MW1600	2-SEPT-92 S003MW1600	21-AUG-92 S003MW3900	19-AUG-92 S003MW4100	21-AUG-92 S003MW6D00
Aluminum	50-200	3915	143	2390	262	94800	605	87600
Arsenic	50	ND	ND	ND	ND	25	ND	ND
Barium	2000	216	168	262	74	849	38.5	911
Beryllium	4	0.555	ND	ND	ND	36.5	ND	36.5
Boron	none	ND	ND	ND	271	2420	408	1930
Calcium	none	85650	93900	141000	107000	*	88200	*
Chromium	100	ND	ND	ND	ND	210	ND	273
Cobalt	none	ND	ND	ND	ND	69	ND	26.1
Copper	1000	50	ND	ND	ND	66.2	ND	77.6
Iron	300	3075	1020	19300	1570	135000	793	111000
Lead	15	9.5	ND	9.32	ND	180	ND	470
Manganese	50	84.6	42.3	377	141	14000	1080	17000
Magnesium	none	27800	36200	35000	32400	830000	9930	750000
Mercury	2	ND	ND	ND	ND	0.299	ND	0.174
Nickel	100	ND	ND	ND	ND	169	ND	152
Potassium	none	6490	4280	3090	4010	125000	2530	122000
Sodium	none	ND	32900	19600	40800	*	15800	*
Vanadium	none	ND	ND	ND	ND	523	ND	523
Tin	5000	94.3	ND	ND	ND	102	ND	94.9
Thallium	2	ND	ND	196	ND	ND	ND	ND
Zinc	5000	163.3	ND	24.2	ND	1470	43.1	1850

**Key:**

All results are in ug/l

ND - Not Detected

\* - This concentration for calcium is > 141000 ug/l; concentration for sodium is > 40800 ug/l

TABLE 5.14 Summary of Organics Present Above MCLs at the Industrial Waste Lagoons									
PARAMETER	MCL (ug/l)	6-DEC-91 S003MW1052	2-SEPT-92 S003MW1052	20-AUG-92 S003MW4000	21-AUG-92 S003MW40DQ	11-DEC-91 S003MW0600	24-NOV-91 S003MW1051	1-SEPT-92 S003MW1051	
1,3-Dimethyl benzene	none	ND	ND	ND	ND	1.8	ND	1.3	
Acetone	none	ND	ND	ND	ND	52	52	ND	
Bis(2-ethylhexyl)phthalate	none	13	ND	ND	ND	ND	ND	ND	
Carbon Disulfide	none	ND	ND	ND	5.6 R	ND	ND	ND	
Phenol	none	5.5	ND	ND	ND	ND	ND	ND	

**Key:**

All results are in ug/l

ND - Not Detected

R - Analysis required for reporting purposes but not certified

TABLE 5.14 (cont.) Summary of Organics Present Above MCLs at the Industrial Waste Lagoons									
PARAMETER	MCL (ug/l)	24-NOV-91 S003MW1053	10-DEC-91 S003MW1600	2-SEPT-92 S003MW1600	21-AUG-92 S003MW3900	19-AUG-92 S003MW4100	21-AUG-92 S003MW6D00		
1,3-Dimethyl benzene	none	ND	ND	ND	1.6	ND	14		
2,4-Dimethyl Phenol	none	ND	ND	ND	ND	ND	13		
Acetone	none	ND	ND	ND	> 100	ND	> 100		
Benzene	5	ND	ND	ND	ND	ND	33		

**Key:**

All results are in ug/l

ND - Not Detected

TABLE 5.15 Summary Of Pesticides Present Above MCLs and/or Background at the Industrial Waste Lagoons

PARAMETER	MCL UG/L	BACKGROUND ug/l	S003MW0600 12/11/91	S003MW1051 11/24/91	S003MW1051 9/1/92	S003MW1052 12/6/91	S003MW1052 9/2/92	S003MW1053 11/24/91	S003MW1600 12/10/91
Alpha - Benzene Hexachloride	none	ND	0.009 U	0.004 U	ND	0.003 C	ND	ND	ND
Alpha - Endosulfan	none	ND	ND	ND	ND	ND	ND	ND	> 0.5
Lindane	0.2	ND	0.005 C	ND	ND	0.008 U	ND	ND	ND

**Key:**

All results are in ug/l

ND - Not Detected

U - Unconfirmed Analysis

C - Confirmed Analysis



**TABLE 5.16**  
**Summary of Inorganics Present above MCLs and/or Background (MW07) at Area B**

		BACKGROUND	6-DEC-91	3-SEPT-92
PARAMETER	MCL ( $\mu\text{g/l}$ )	g/l	AOOBMW1123	AOOBMW1123
Aluminum	50-200	3915	6450	65100
Antimony	6	ND	73.2	ND
Arsenic	50	ND	ND	10.9
Barium	2000	216	62.4	307
Beryllium	4	0.555	ND	3.02
Boron	none	ND	ND	305
Calcium	none	85650	162000	210000
Chromium	100	ND	71	139
Cobalt	none	ND	ND	35.9
Copper	1000	50	ND	55.5
Iron	300	3075	17600	84000
Lead	15	9.5	11.6	95.4
Manganese	50	84.6	4740	5120
Magnesium	none	27800	21000	40600
Nickel	100	ND	ND	97.9
Potassium	none	6490	4310	26600
Sodium	none	60000	10100	17400
Vanadium	none	ND	ND	85.4
Zinc	5000	94.3	48.4	244

Key:  
 All results are in  $\mu\text{g/l}$   
 ND = Not Detected

**TABLE 5.17**  
**Summary of Organics Present above MCLs at Area B**

		BACKGROUND	6-DEC-91	3-SEPT-92
PARAMETER	MCL ( $\mu\text{g/l}$ )	$\mu\text{g/l}$	AOOB MW1123	AOOB MW1123
1,3-Dimethyl Benzene	none	ND	ND	2.2
Phenol	none	ND	ND	17
Key: All results are in $\mu\text{g/l}$ ND = Not Detected U = Unconfirmed Analysis C = Confirmed analysis				

**TABLE 5.18**  
**Summary of Pesticides Present above MCLs and/or Background (MW07) at Area B**

	MCL	BACKGROUND	A00BMW1123	A00BMW1123
PARAMETER	Mg/L	$\mu\text{g/l}$	12/6/91	9/3/92
DDT	none	0.013	0.008 C	ND

**Key:**

All results are in  $\mu\text{g/l}$

ND = Not detected

U = Unconfirmed analysis

C = Confirmed analysis

D = Duplicate analysis or test name

**TABLE 5.19**  
**Summary of Inorganics Present above MCLs and/or Background (MW07) at Area C**

		BACKGROUND	5-DEC-91	2-SEPT-92
PARAMETER	MCL ( $\mu\text{g/l}$ )	$\mu\text{g/l}$	AOOCMW1009	AOOCMW1009
Aluminum	50-200	3915	24300	15900
Arsenic	50	ND	ND	3.32
Beryllium	4	0.555	1.65	ND
Boron	none	ND	ND	389
Calcium	none	85650	80400	33600
Chromium	100	ND	34.4	42.5
Iron	300	3075	37,800	16400
Lead	15	9.5	25.1	19.3
Manganese	50	84.6	764	288
Magnesium	none	27800	22700	15500
Nickel	100	ND	38.3	ND
Potassium	none	6490	11600	8700
Sodium	none	60000	55000	94000
Vanadium	none	ND	42.2	ND
Zinc	5000	94.3	103	66.7

Key:  
All results are in  $\mu\text{g/l}$   
ND - Not Detected

**TABLE 5.20**  
**Summary of Organics Present above MCLs at Area C**

		5-DEC-91	2-SEPT-92
PARAMETER	MCL ( $\mu\text{g/l}$ )	AOOCMW1009	AOOCMW1009
1,3-Dimethyl Benzene	none	ND	1.3
Chloromethane	none	4.4	ND

**Key:**

All results are in  $\mu\text{g/l}$

ND = Not Detected

U = Unconfirmed Analysis

C = Confirmed Analysis

D

13,842,000N — 2,406,000E

C

MW-19DD

Aluminum	350000
Antimony	217
Chromium	448
Cobalt	186
Iron	342000
Manganese	65000
Magnesium	980000
Molybdenum	58.8
Nickel	427
Thallium	437
Tin	62.9
Tellurium	211
Vanadium	237

MW-47

Aluminum	44200
Iron	39100
Lead	106
Manganese	324
Magnesium	8440
Vanadium	34.1

MW-04

Aluminum	22900
Antimony	63
Cobalt	32.6
Iron	51200
Lead	101
Manganese	1000
Magnesium	18400
Vanadium	39.8

(2)

+

+

**MW-19DD**

Aluminum	350000
Antimony	217
Chromium	448
Cobalt	186
Iron	342000
Manganese	65000
Magnesium	980000
Molybdenum	58.8
Nickel	427
Thallium	437
Tin	62.9
Tellurium	211
Vanadium	237

**MW-19**

Aluminum	1220
Iron	3060
Manganese	252
Magnesium	13900

**MW-47**

Aluminum	44200
Iron	39100
Lead	106
Manganese	324
Magnesium	8440
Vanadium	34.1

**MW-04**

Aluminum	22900
Antimony	63
Cobalt	32.6
Iron	51200
Lead	101
Manganese	1000
Magnesium	18400
Vanadium	39.8

**MW-8D**

Aluminum	512
Iron	7910
Manganese	626
Magnesium	20000

**MW-112**

Aluminum	
Iron	
Manganese	
Magnesium	

**MW-02**

Aluminum	992
Iron	3590
Lead	21.3
Manganese	162
Magnesium	36600

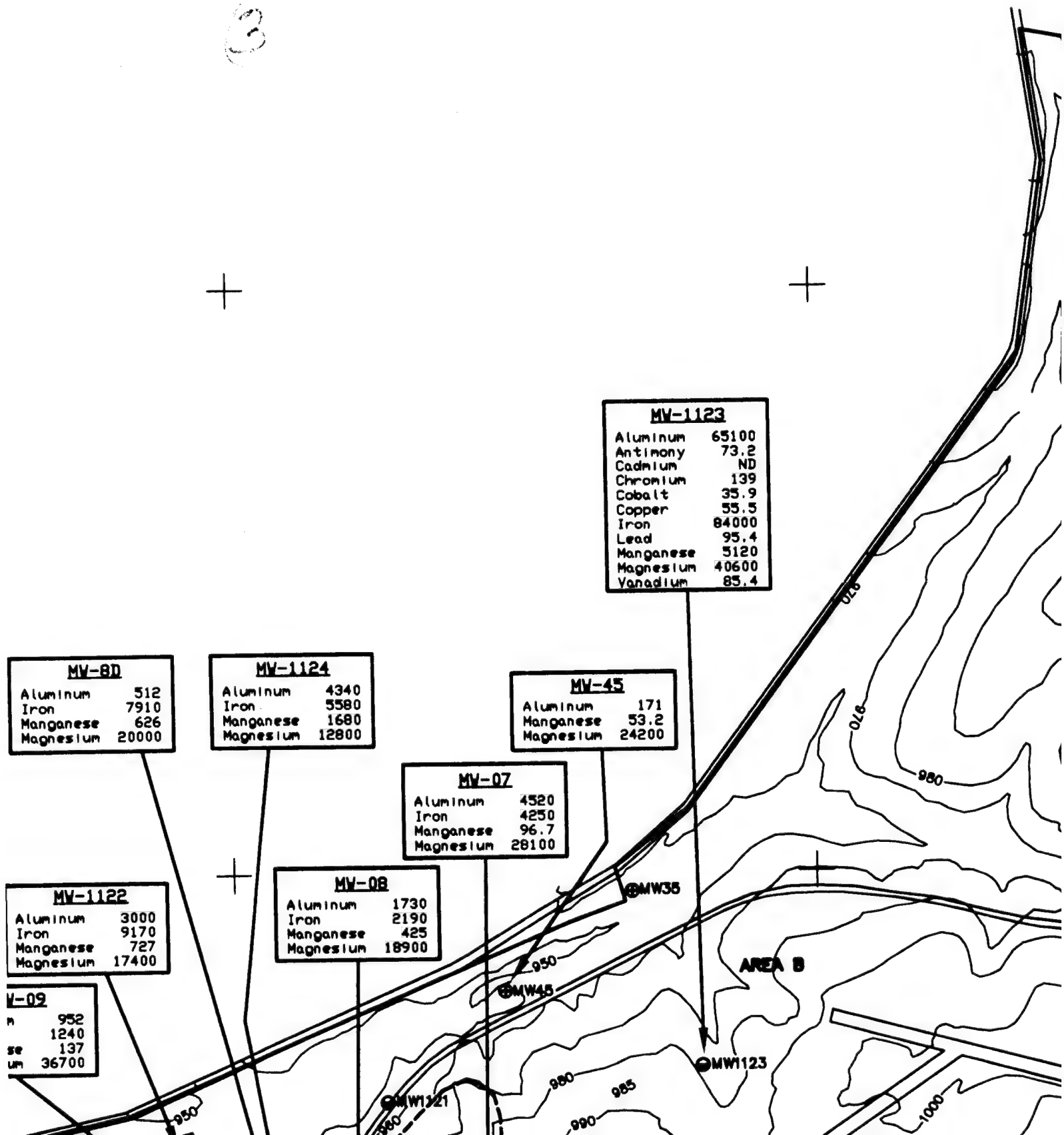
**MW-1122**

Aluminum	3000
Iron	9170
Manganese	727
Magnesium	17400

**MW-09**

Aluminum	952
Iron	1240
Manganese	137
Magnesium	36700

Alum	
Iron	
Mang	
Magn	





4

**MW-1009**

Aluminum	24300
Iron	37800
Lead	25.1
Manganese	764
Magnesium	22700
Vanadium	42.2

MW1009

AREA C

**-1123**

Alt	65100
Temp	73.2
ND	ND
Flow	139
Pressure	35.9
Flow	55.5
Pressure	84000
Flow	95.4
Pressure	5120
Flow	40600
Pressure	85.4

MW1123

AREA B

NEW LA

MW220

MW22

MW11

5

**MV-1009**

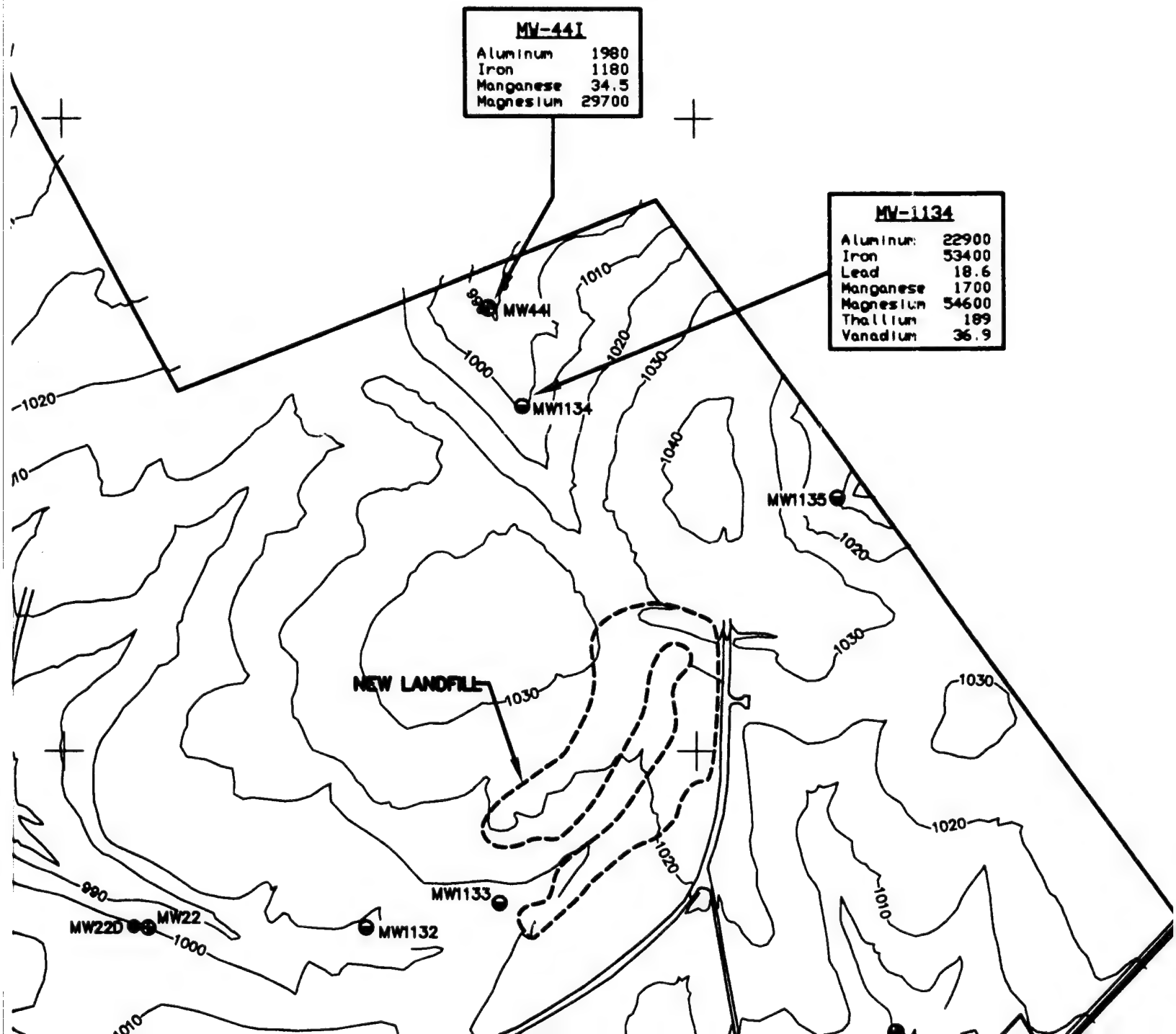
Aluminum	24300
Iron	37800
Lead	25.1
Manganese	764
Magnesium	22700
Vanadium	42.2

**MV-44I**

Aluminum	1980
Iron	1180
Manganese	34.5
Magnesium	29700

**MV-1134**

Aluminum	22900
Iron	53400
Lead	18.6
Manganese	1700
Magnesium	54600
Thallium	189
Vanadium	36.9



6



2,418,000E  
13,842,000N

**MV-1134**

Aluminum	22900
Iron	53400
Cad	18.6
Manganese	1700
Magnesium	54600
Sodium	189
Strontium	36.9

1030

1020

1010

D

C

C 7

Aluminum	44200
Iron	39100
Lead	106
Manganese	324
Magnesium	8440
Vanadium	34.1

<b>MW-04</b>	
Aluminum	22900
Antimony	63
Cobalt	32.6
Iron	51200
Lead	101
Manganese	1000
Magnesium	18400
Vanadium	39.8

<b>MW-03</b>	
Aluminum	1360
Iron	3070
Manganese	74.2
Magnesium	9870

<b>MW-42</b>	
Aluminum	285
Iron	2380
Manganese	124
Magnesium	11600

<b>MW-60</b>	
Aluminum	87600
Beryllium	36.5
Chromium	273
Cobalt	26.1
Iron	111000
Lead	470
Manganese	17000
Magnesium	750000
Nickel	152
Tin	34.9
Vanadium	523

<b>MW-16</b>	
Aluminum	2390
Iron	19300
Manganese	377
Magnesium	35000
Thallium	196

<b>MW-1053</b>	
Aluminum	143
Iron	1020
Manganese	42.3
Magnesium	36200

<b>WSV-8</b>	
Manganese	143
Magnesium	15300

<b>MW-1051</b>	
Aluminum	3500
Cadmium	7.22
Iron	8940
Manganese	342
Magnesium	31200

<b>MW-06</b>	
Aluminum	2470
Iron	3200
Manganese	306
Magnesium	54200

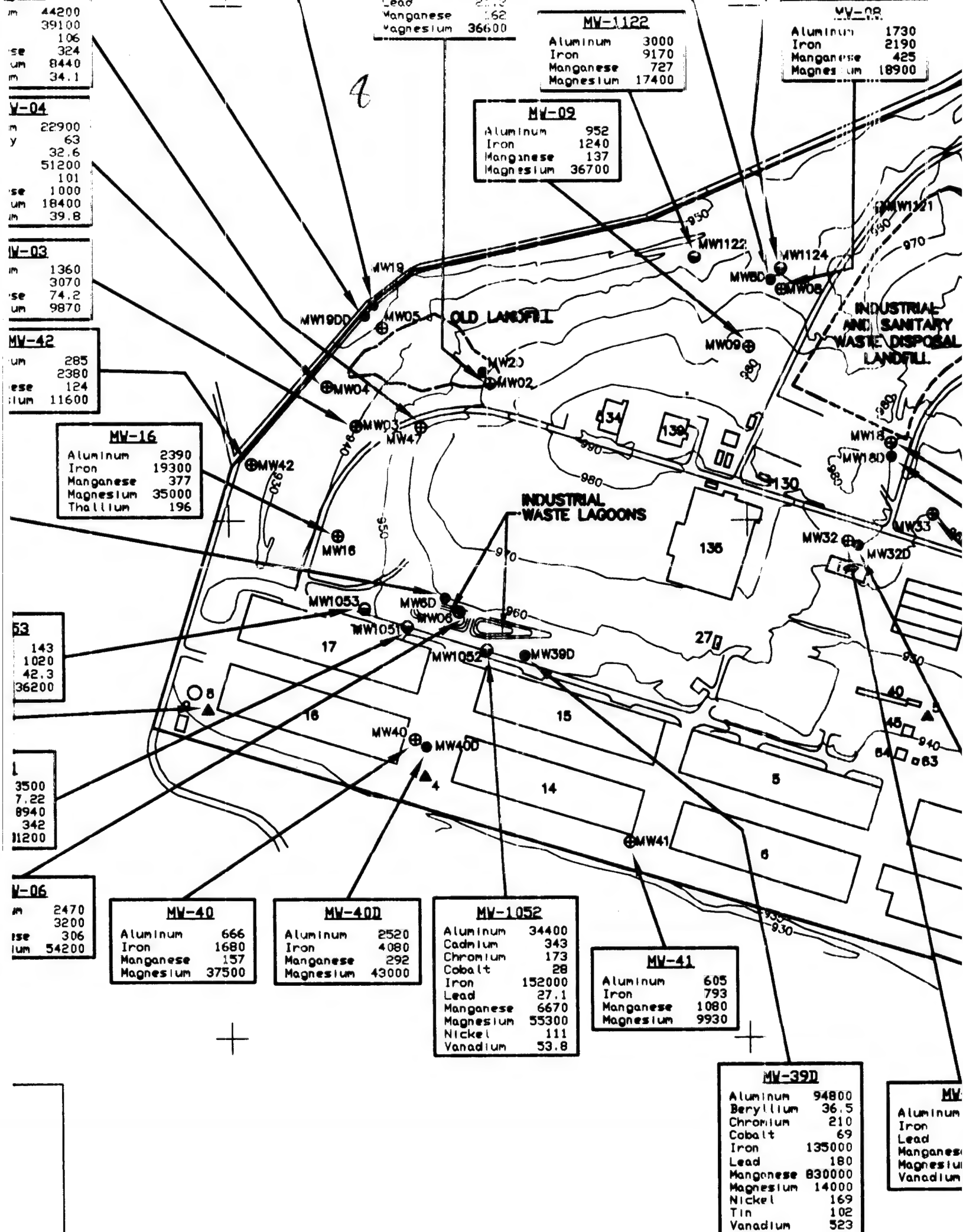
<b>MW-40</b>	
Aluminum	66
Iron	168
Manganese	15
Magnesium	3750

13,836,000N 2,406,000E

B

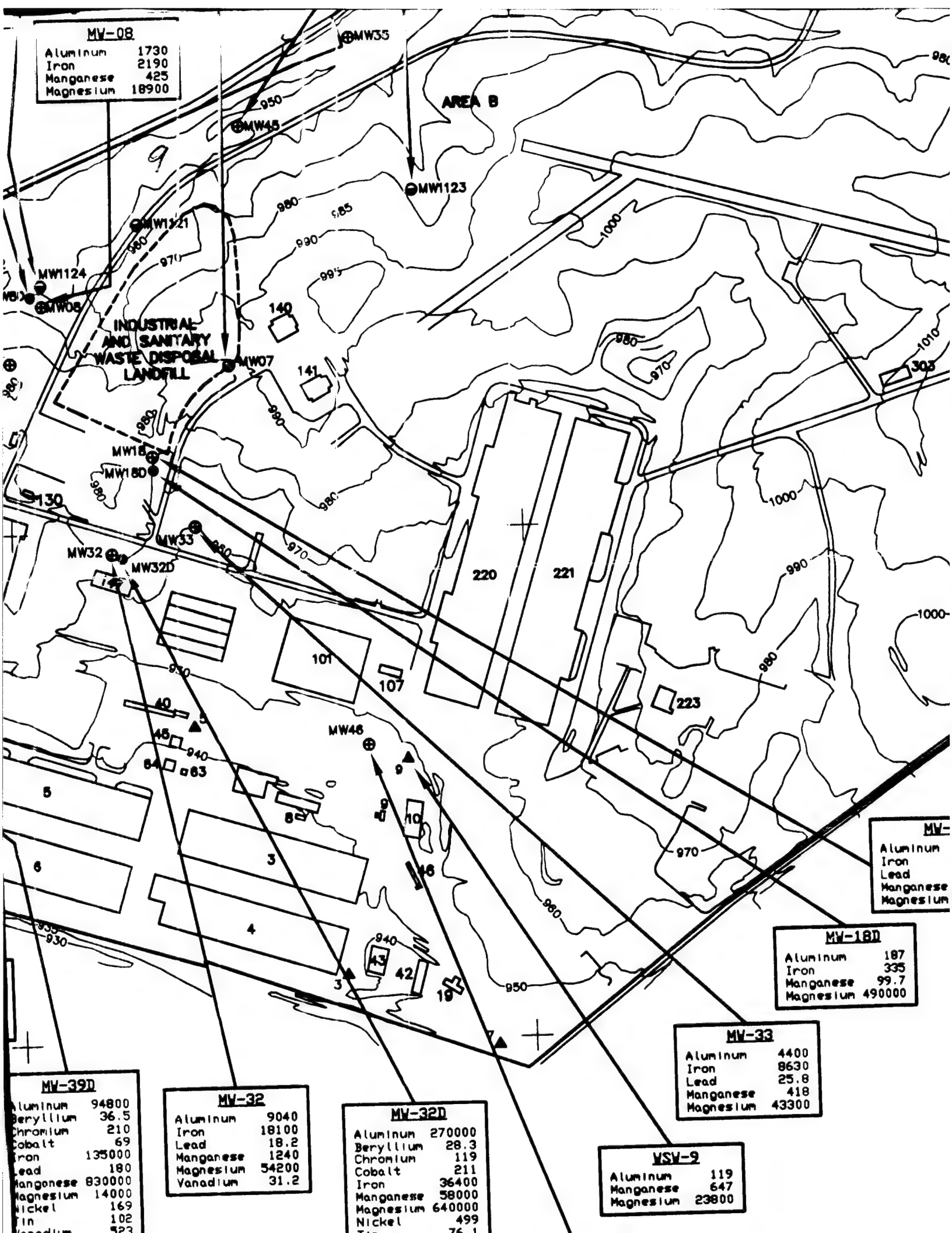
**LEGEND**

- EXISTING WELLS
- ⊕ SHALLOW WELLS
- DEEP WELLS



**MV-08**

Aluminum	1730
Iron	2190
Manganese	425
Magnesium	18900



INDUSTRIAL  
AND SANITARY  
WASTE DISPOSAL  
LANDFILL

AREA B

**MV-**

Aluminum	
Iron	
Lead	
Manganese	
Magnesium	

**MW-18D**

Aluminum	187
Iron	335
Manganese	99.7
Magnesium	490000

**MV-33**

Aluminum	4400
Iron	8630
Lead	25.8
Manganese	418
Magnesium	43300

**WSV-9**

Aluminum	119
Manganese	647
Magnesium	23800

**MV-39D**

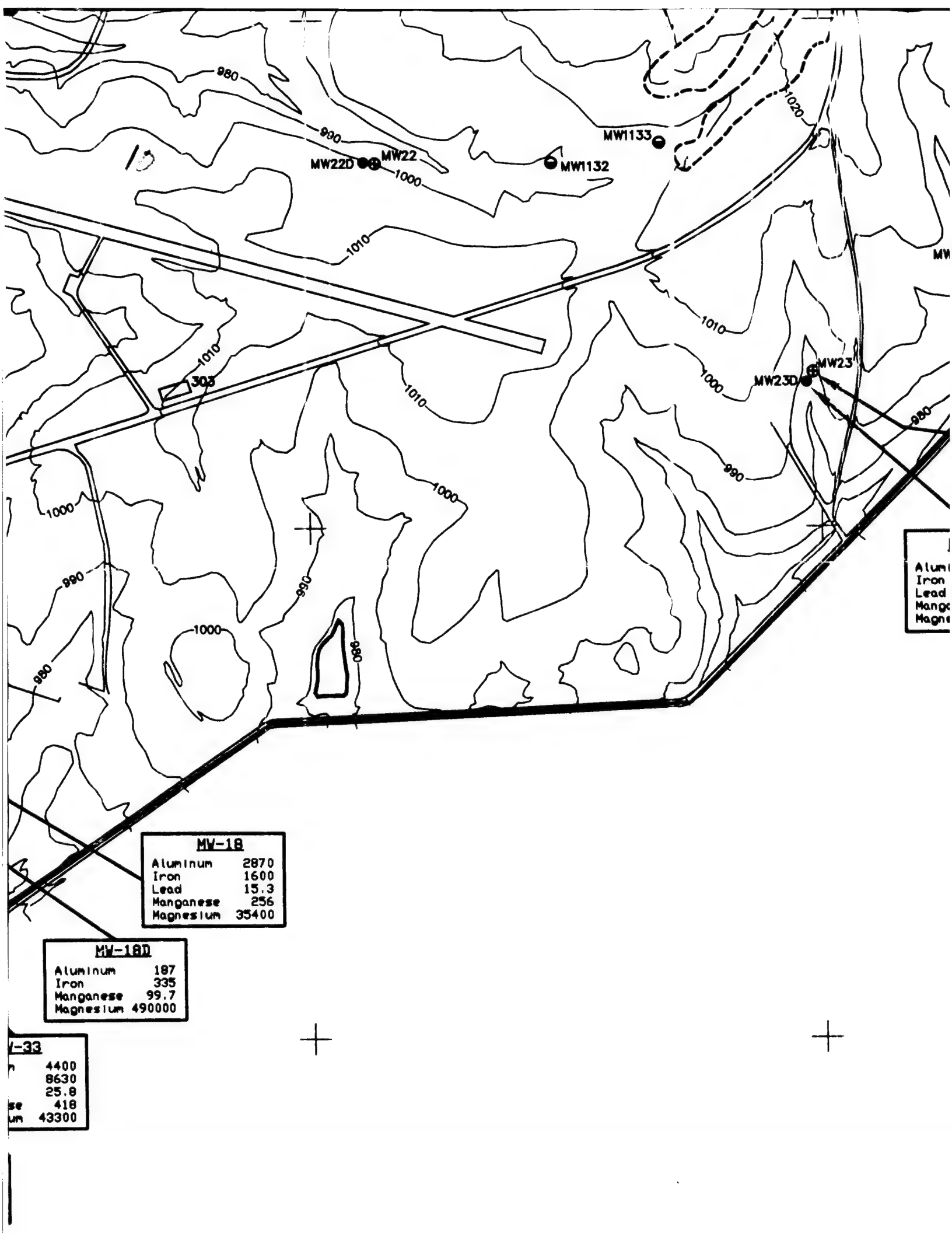
Aluminum	94800
Beryllium	36.5
Chromium	210
Cobalt	69
Iron	135000
Lead	180
Manganese	830000
Magnesium	14000
Nickel	169
Tin	102
Vanadium	523

**MV-32**

Aluminum	9040
Iron	18100
Lead	18.2
Manganese	1240
Magnesium	54200
Vanadium	31.2

**MV-32D**

Aluminum	270000
Beryllium	28.3
Chromium	119
Cobalt	211
Iron	36400
Manganese	58000
Magnesium	640000
Nickel	499
Tin	76.1

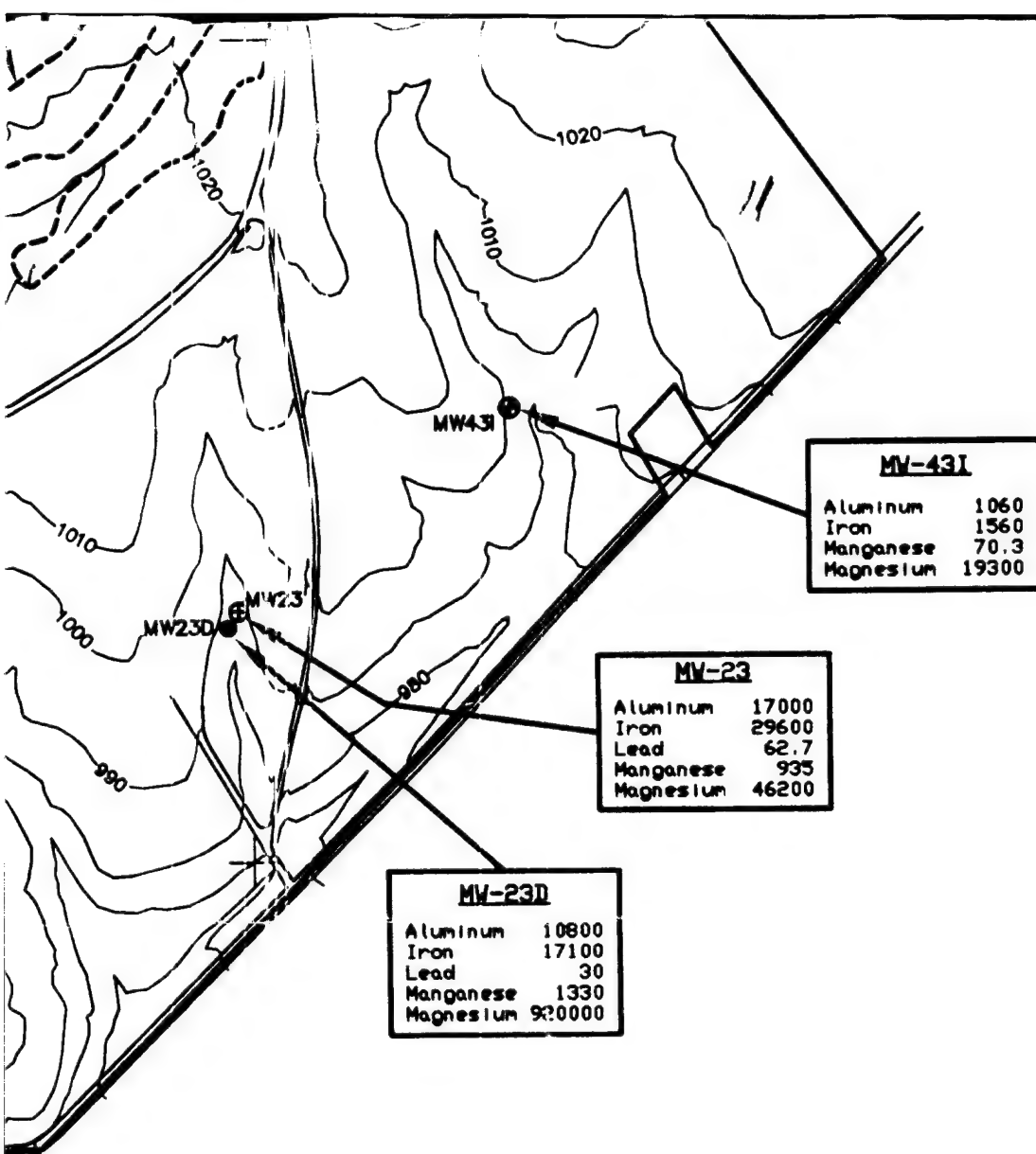


Alum  
Iron  
Lead  
Mang  
Magn

MV-18	
Aluminum	2870
Iron	1600
Lead	15.3
Manganese	256
Magnesium	35400

MV-18D	
Aluminum	187
Iron	335
Manganese	99.7
Magnesium	490000

I-33	
Aluminum	4400
Iron	8630
Lead	25.8
Manganese	418
Magnesium	43300



2,418,000E

13,836,000N



12

C

MW-43I	
Aluminum	1060
Iron	1560
Manganese	70.3
Magnesium	19300

17000
29600
62.7
935
46200

B

2,418,000E

13,836,000N

B

13

**WSW-8**  
Manganese 143  
Magnesium 15300

**MV-1053**  
Aluminum 143  
Iron 1020  
Manganese 42.3  
Magnesium 36200

**MV-1051**  
Aluminum 3500  
Cadmium 7.22  
Iron 8940  
Manganese 342  
Magnesium 31200

**MV-06**  
Aluminum 2470  
Iron 3200  
Manganese 306  
Magnesium 54200

**MV-**  
Aluminum  
Iron  
Manganese  
Magnesium

13,836,000N | 2,406,000E

A

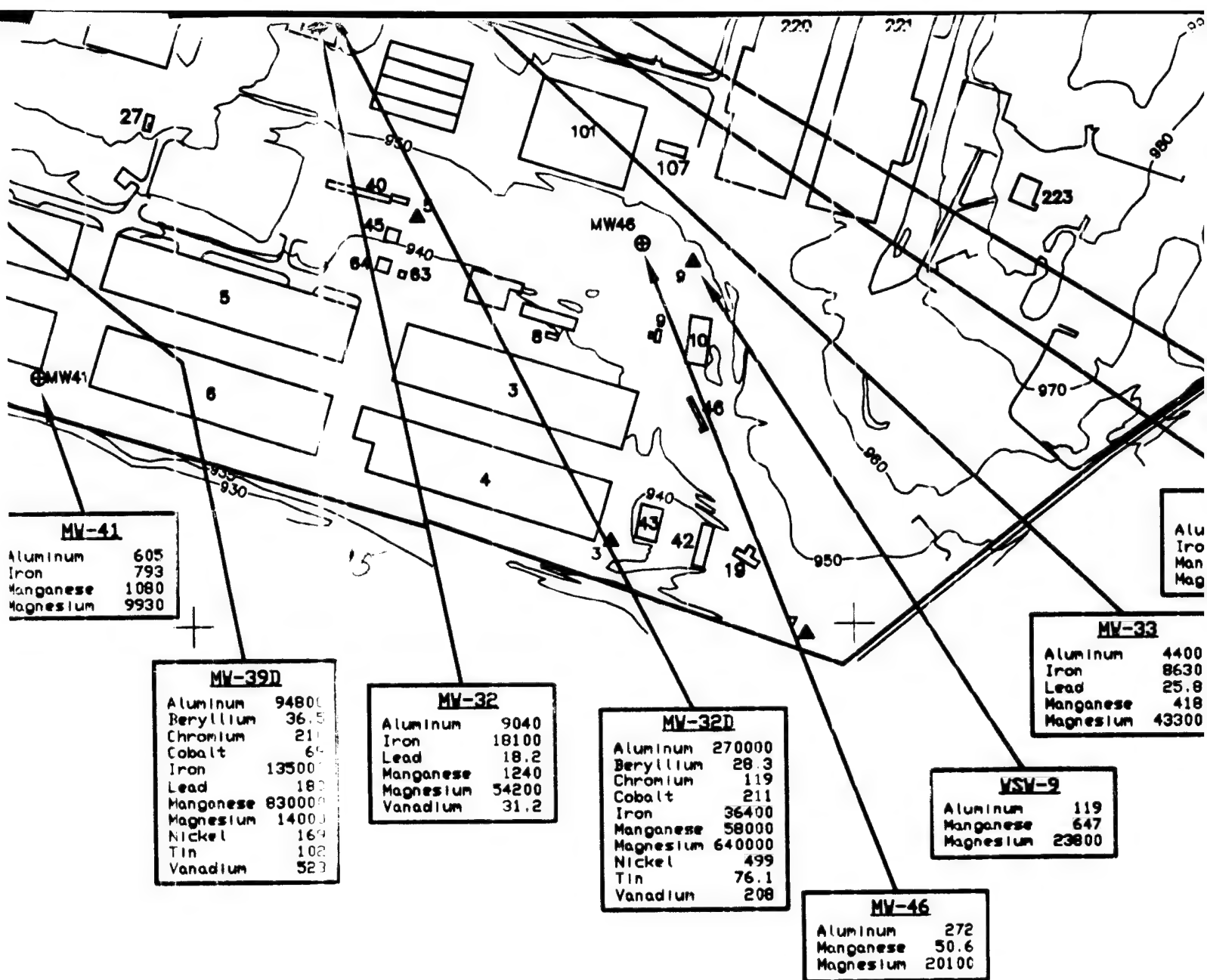
**LEGEND**

- EXISTING WELLS
- ⊕ SHALLOW WELLS
- DEEP WELLS
- ⊕ BEDROCK INTERFACE WELL
- ▲ PRODUCTION WELL
- - - BOUNDARY LINE

NOTE: ALL CONCENTRATIONS IN ug/l

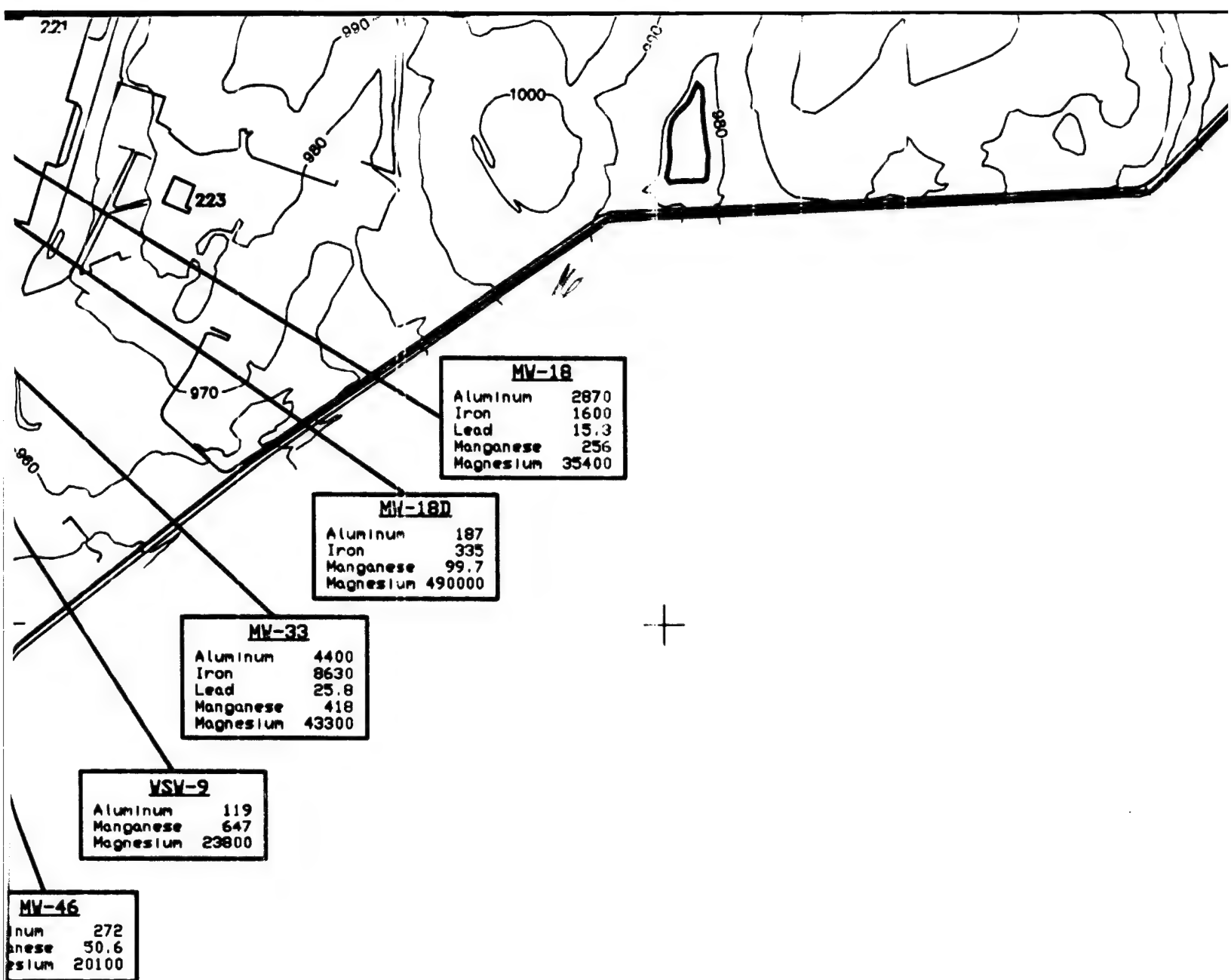
NUMBER	DATE	MADE BY	CHECKED BY	DESCRIPTION
REVISIONS				





**M&E** Metcalf & E

REG. PROF. ENGR.



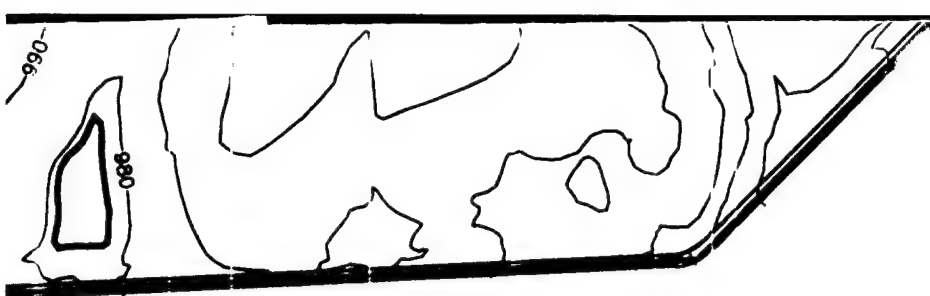
**Metcalf & Eddy**

SCALE: 1" = 437.44'



DATE

UNLESS OTHERWISE NOTED OR CHANGED BY REPRODUCTION



Aluminum	30800
Iron	27100
Lead	8
Manganese	103
Magnesium	9200



Scale: 1" = 437.44'



LEXINGTON BLUEGRASS ARMY (CAMP)  
INORGANICS DETECTED  
GROUNDWATER ABOVE MCL  
LEXINGTON, KENTUCKY

AS OTHERWISE NOTED OR CHANGED BY REPRODUCTION

Aluminum 10800  
Iron 17100  
Lead 80  
Manganese 10000  
Magnesium 920000

+

2,418,000E

13,836,000N

LEXINGTON BLUEGRASS ARMY DEPOT  
  
INORGANICS DETECTED IN  
GROUNDWATER ABOVE MCLS  
  
LEXINGTON, KENTUCKY

JOB 012308

FILE NO. INMAP

FIGURE 5-1

2,418,000E

13,836,000N

B

A

OT

S

JOB 012308

FILE NO. INMAP

FIGURE 5-1



D

13,842,000N

2,406,000E

C

2

2

+

+

+

+

**MV-47**  
Acetone GT100

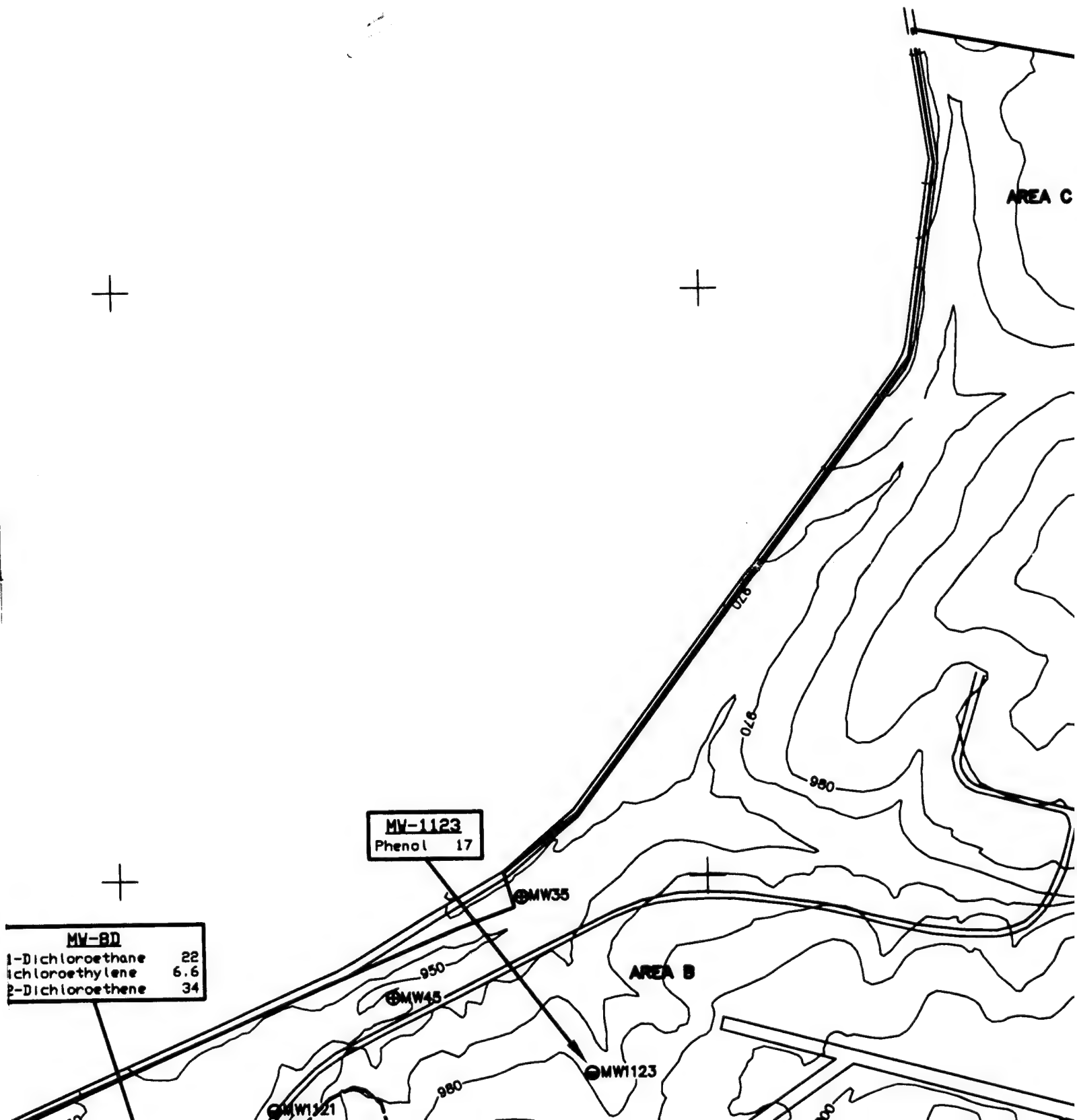
**MV-08**  
1,1-Dichloroethane 9

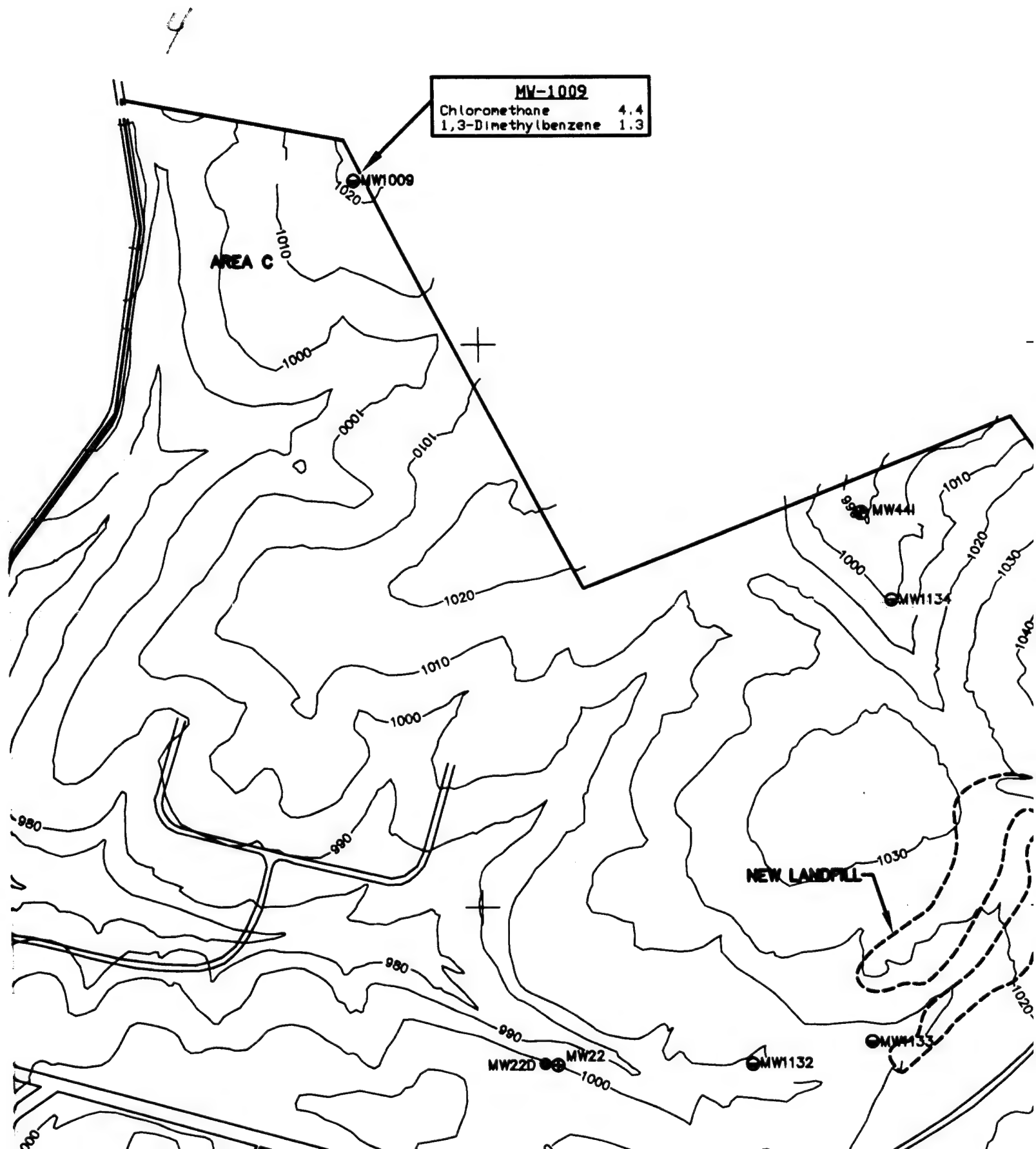
**MV-8D**  
1,1-Dichloroethane 22  
Trichloroethylene 6.6  
1,2-Dichloroethene 34

MW121

950

960





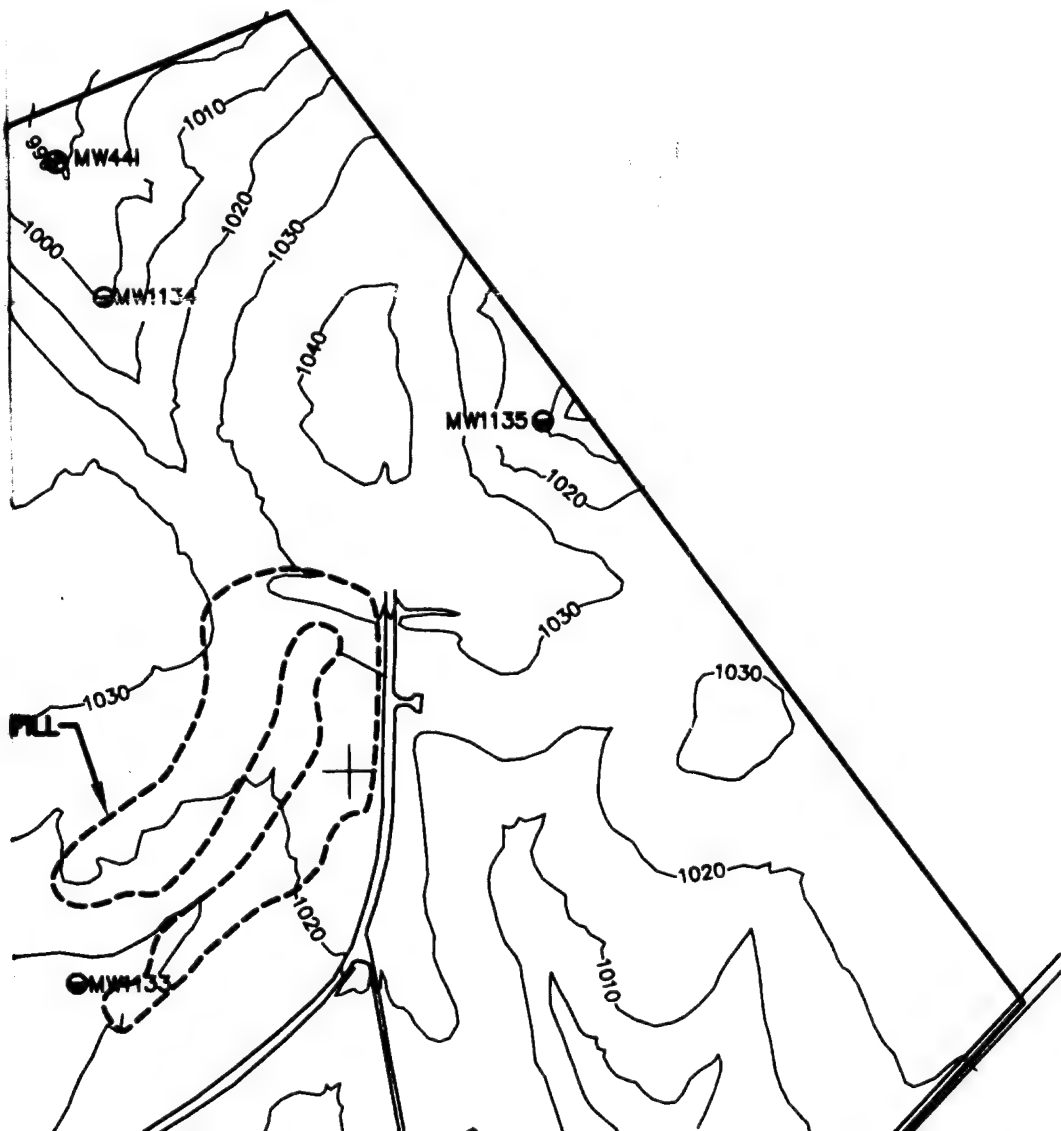
5

6



2,418,000E

13,842,000N



6

←

2,418,000E

13,842,000N

D

C

C

7

B

13,836,000N

2,406,000E

**MV-19DD**

Methyl Isobutyl Ketone  
2,4-Dimethylphenol  
2-Hexanone

**MV-6D**

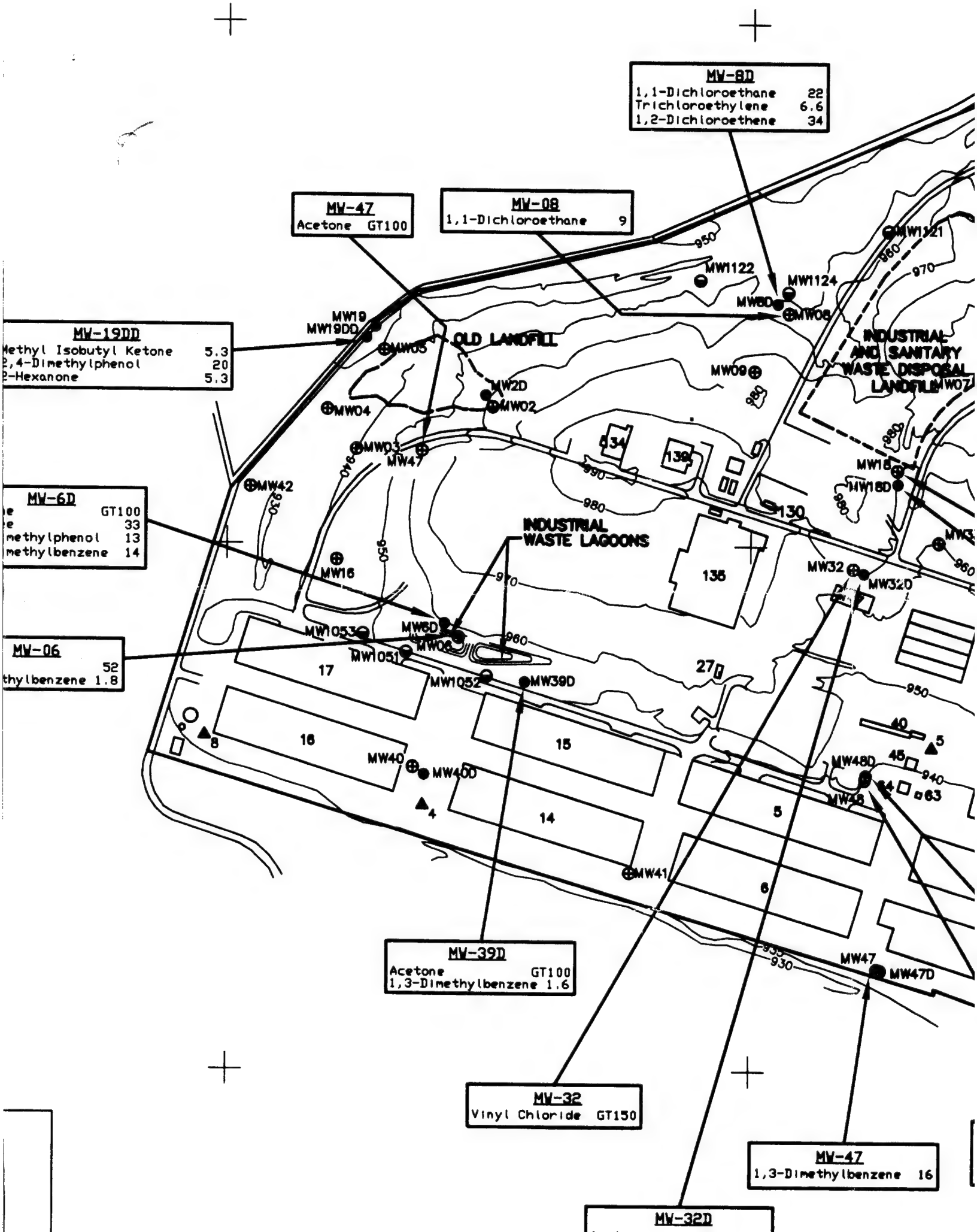
Acetone	GT100
Benzene	33
2,4-Dimethylphenol	13
1,3-Dimethylbenzene	14

**MV-06**

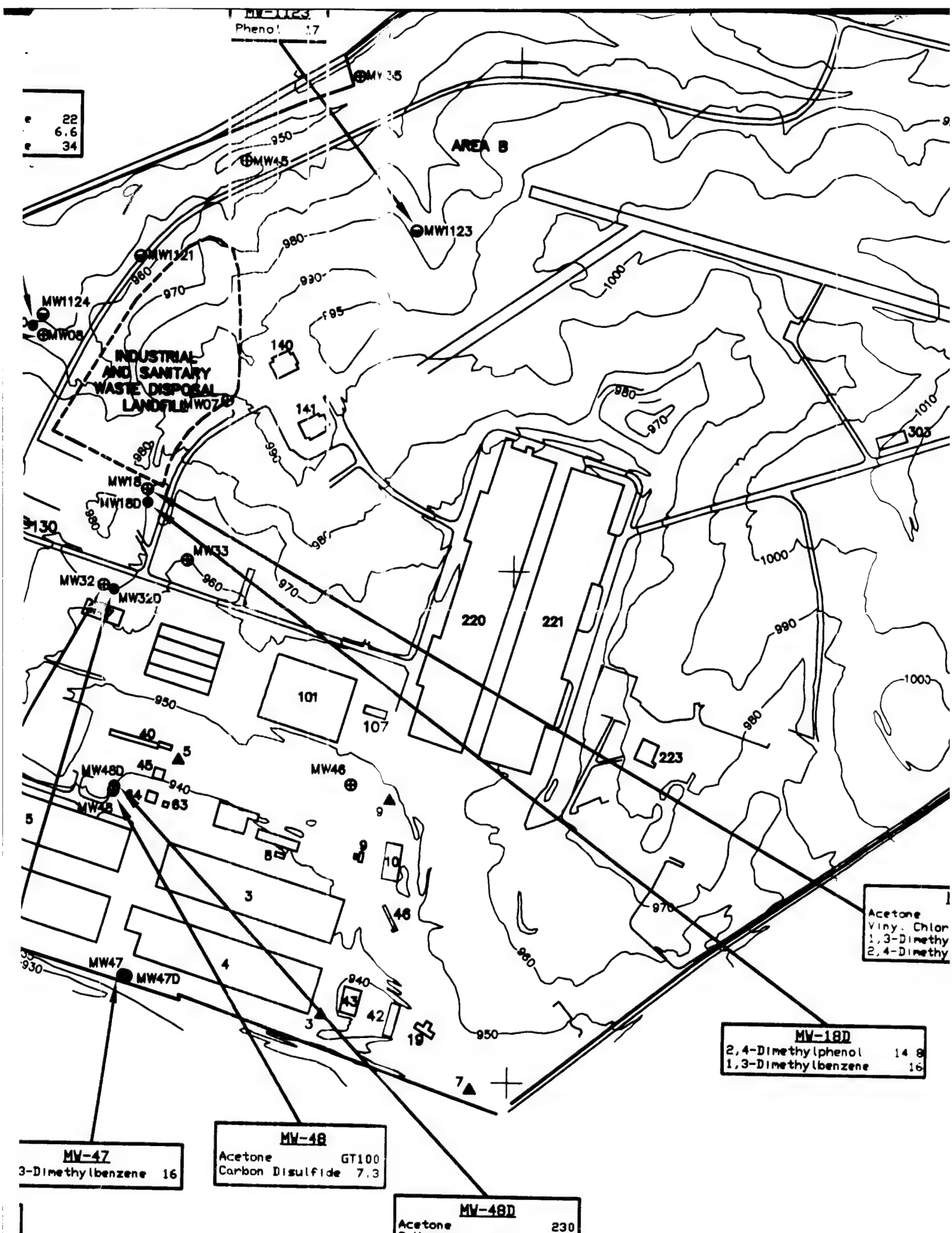
Acetone	52
1,3-Dimethylbenzene	1.8

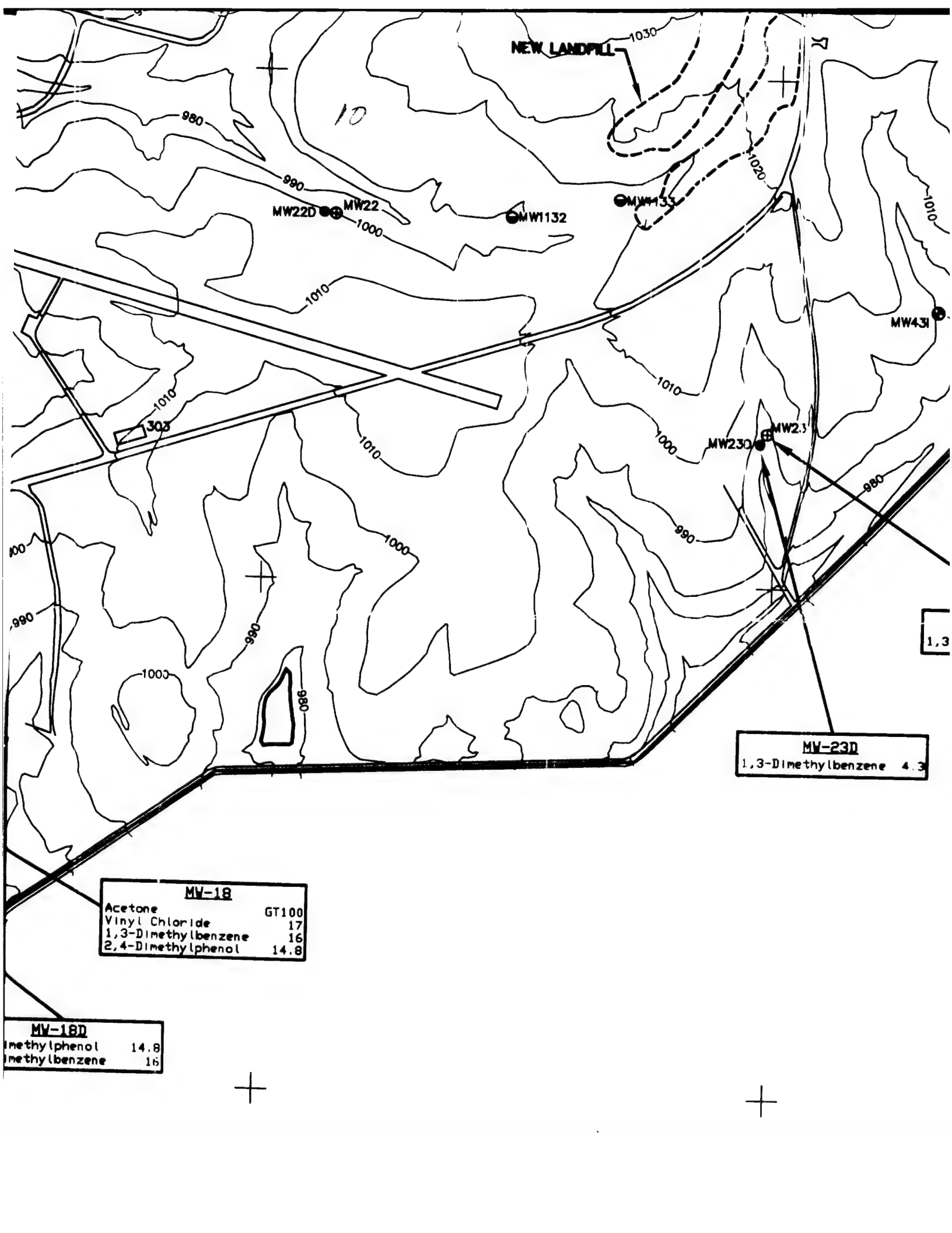
**LEGEND**

- EXISTING WELLS
- ⊕ SHALLOW WELLS









NEW LANDFILL

MW22D MW22

MW1132

MW133

MW431

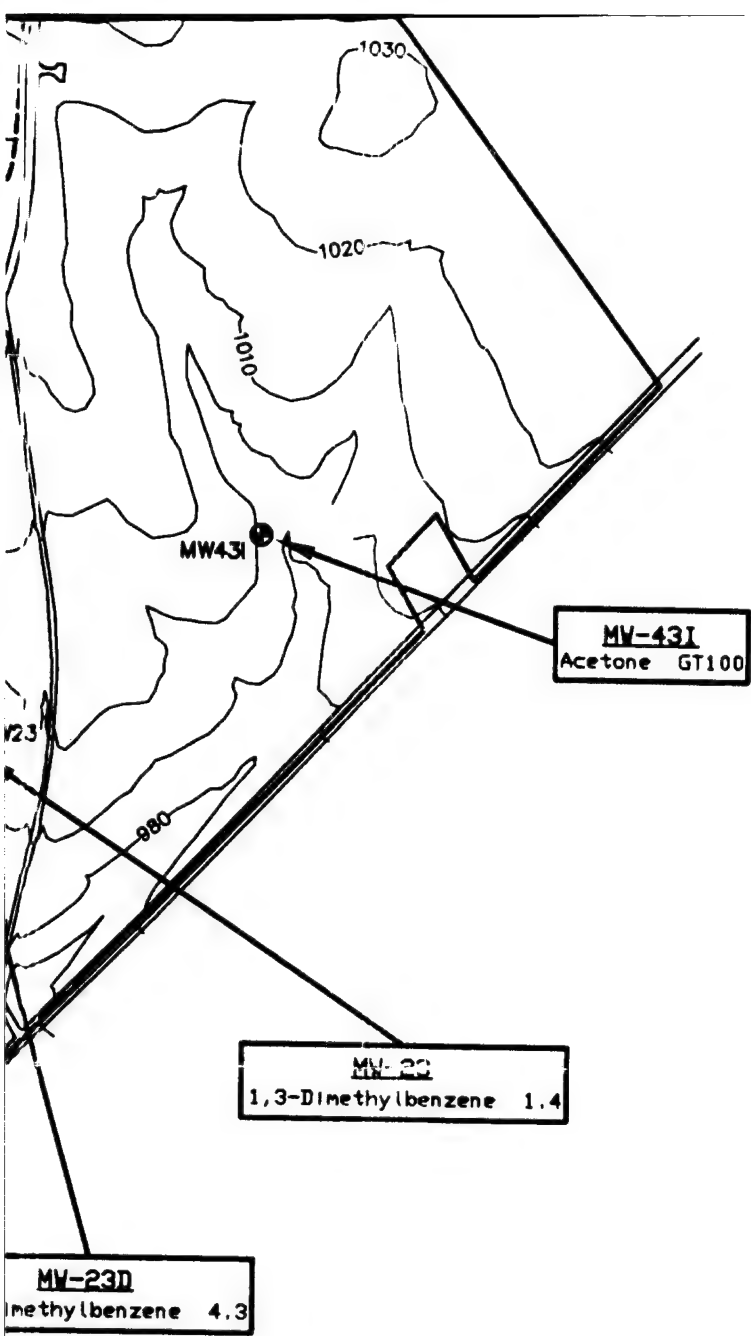
MW230

MW231

MW-23D  
1,3-Dimethylbenzene 4.3

MW-18  
Acetone GT100  
Vinyl Chloride 17  
1,3-Dimethylbenzene 16  
2,4-Dimethylphenol 14.8

MW-18D  
1-methylphenol 14.8  
1-methylbenzene 16



2,418,000E

13,836,000N

100

2,418,000E

13,836,000N

C

B

B

13

MV-06	
Acetone	52
1,3-Dimethylbenzene	1.8

13,836,000N | 2,406,000E

A

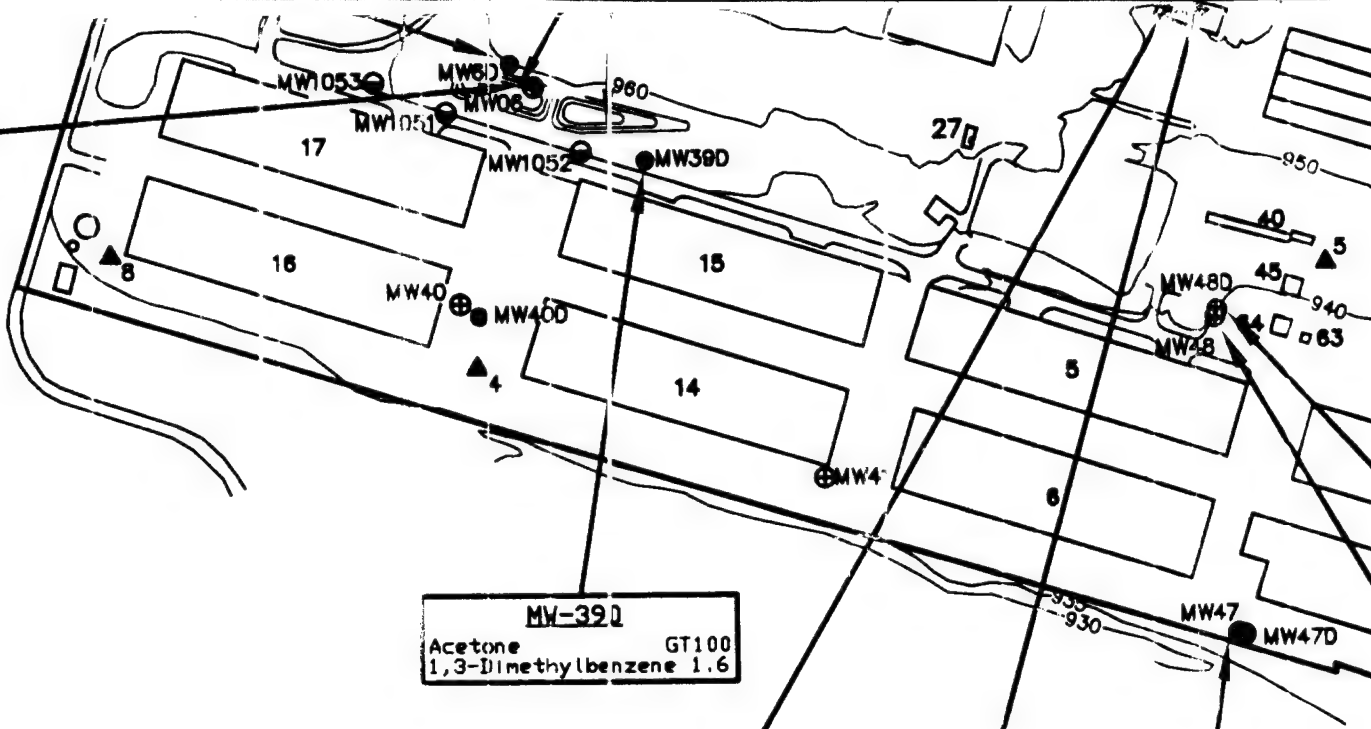
### LEGEND

- EXISTING WELLS
- ⊕ SHALLOW WELLS
- DEEP WELLS
- BEDROCK INTERFACE WELL
- ▲ PRODUCTION WELL
- - - BOUNDARY LINE

NOTE: ALL CONCENTRATIONS IN ug/l

NUMBER	DATE	MADE BY	CHECKED BY	DESCRIPTION
REVISIONS				

MW-06  
52  
thylbenzene 1.8



MW-39D  
Acetone GT100  
1,3-Dimethylbenzene 1.6

MW-32  
Vinyl Chloride GT150

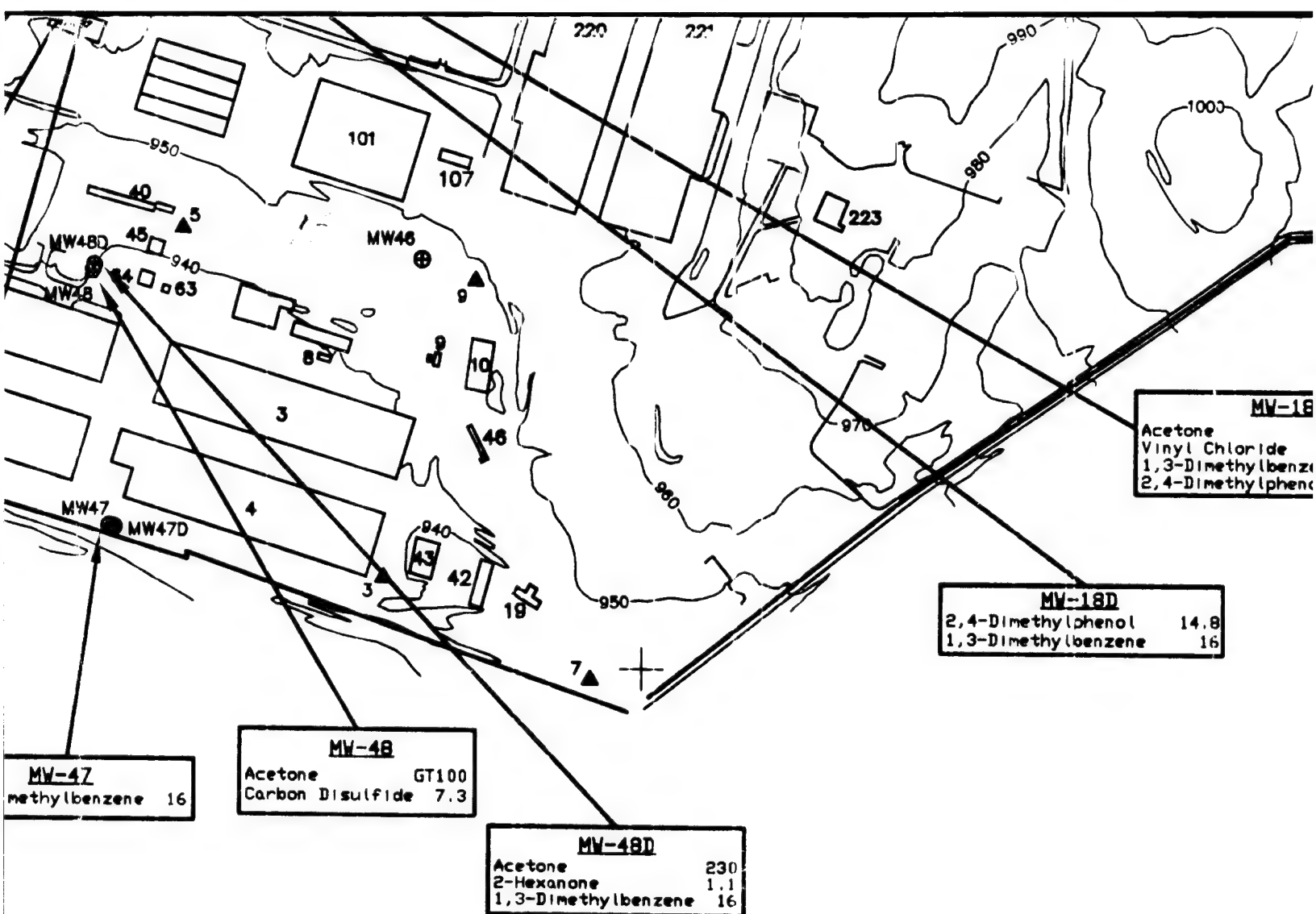
MW-32D  
Acetone GT100  
Benzene 6.9  
1,3-Dimethylbenzene 5.8

MW-47  
1,3-Dimethylbenzene 16

CE

1 ug/l

	DRAWN BY	
	CAP	
	DEPT. CHECK	
	PROJ. CHECK	
DESCRIPTION		



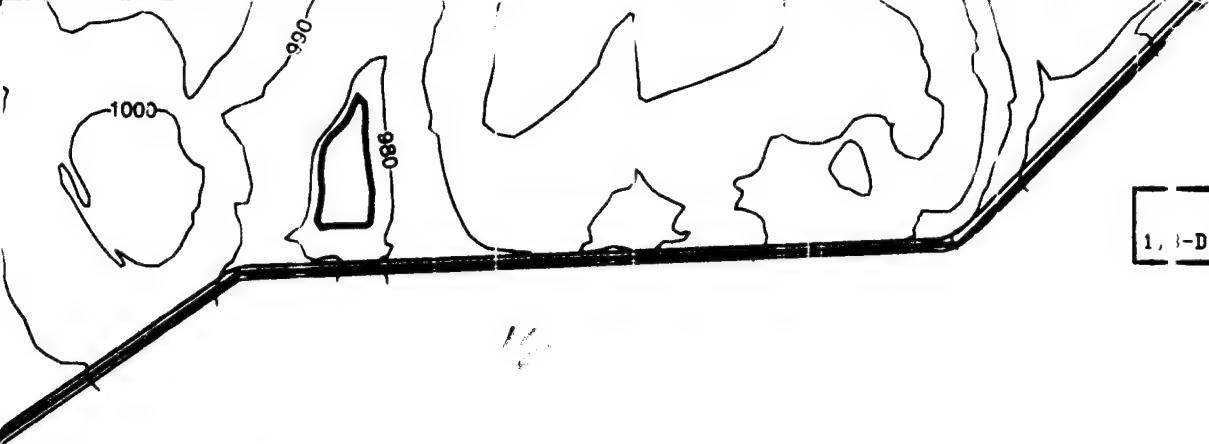
**M&E** Metcalf & Eddy

SCALE

REG. PROF. ENGR.

DATE

UNLESS

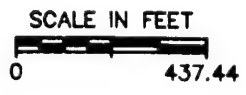


MV-23D  
1,3-Dimethylbenzene 4.3

MV-18  
Acetone GT100  
Vinyl Chloride 17  
1,3-Dimethylbenzene 16  
2,4-Dimethylphenol 14.8

BD  
enol 14.8  
nzene 16

SCALE: 1" = 437.44'



LEXINGTON BLUEG

ORGANICS D  
GROUNDWATER

LEXINGTON

DATE

UNLESS OTHERWISE NOTED OR CHANGED BY REPRODUCTION



ne 4.0

B

2,418,000E

13,836,000N

A

INGTON BLUEGRASS ARMY DEPOT

ORGANICS DETECTED IN  
UNDERGROUND WATER ABOVE MCLS

LEXINGTON, KENTUCKY

JOB 012308

FILE NO. ORGMAP

FIGURE 5-2

1

C

D

13,842,000N —

2,406,000E

1

②

+

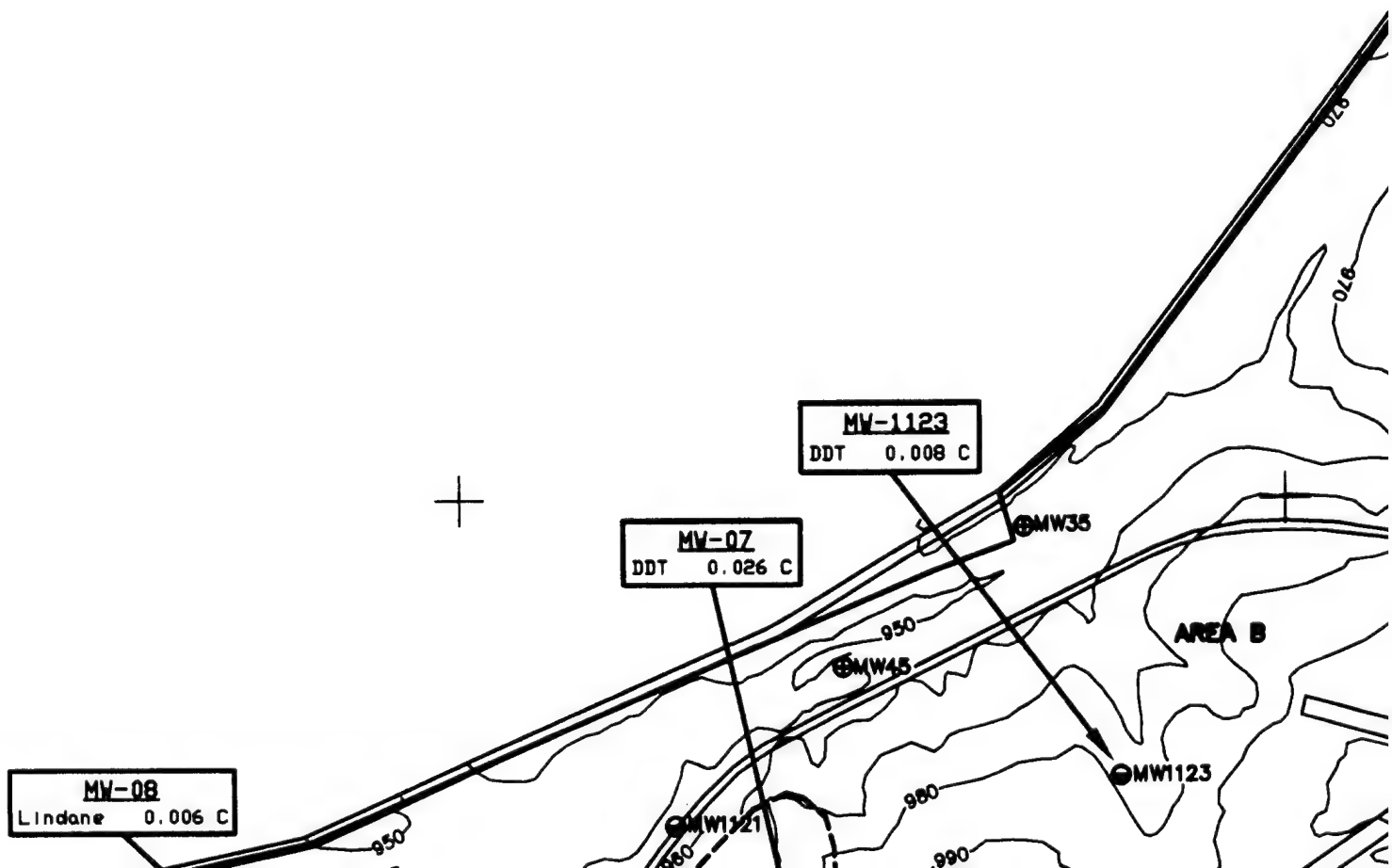
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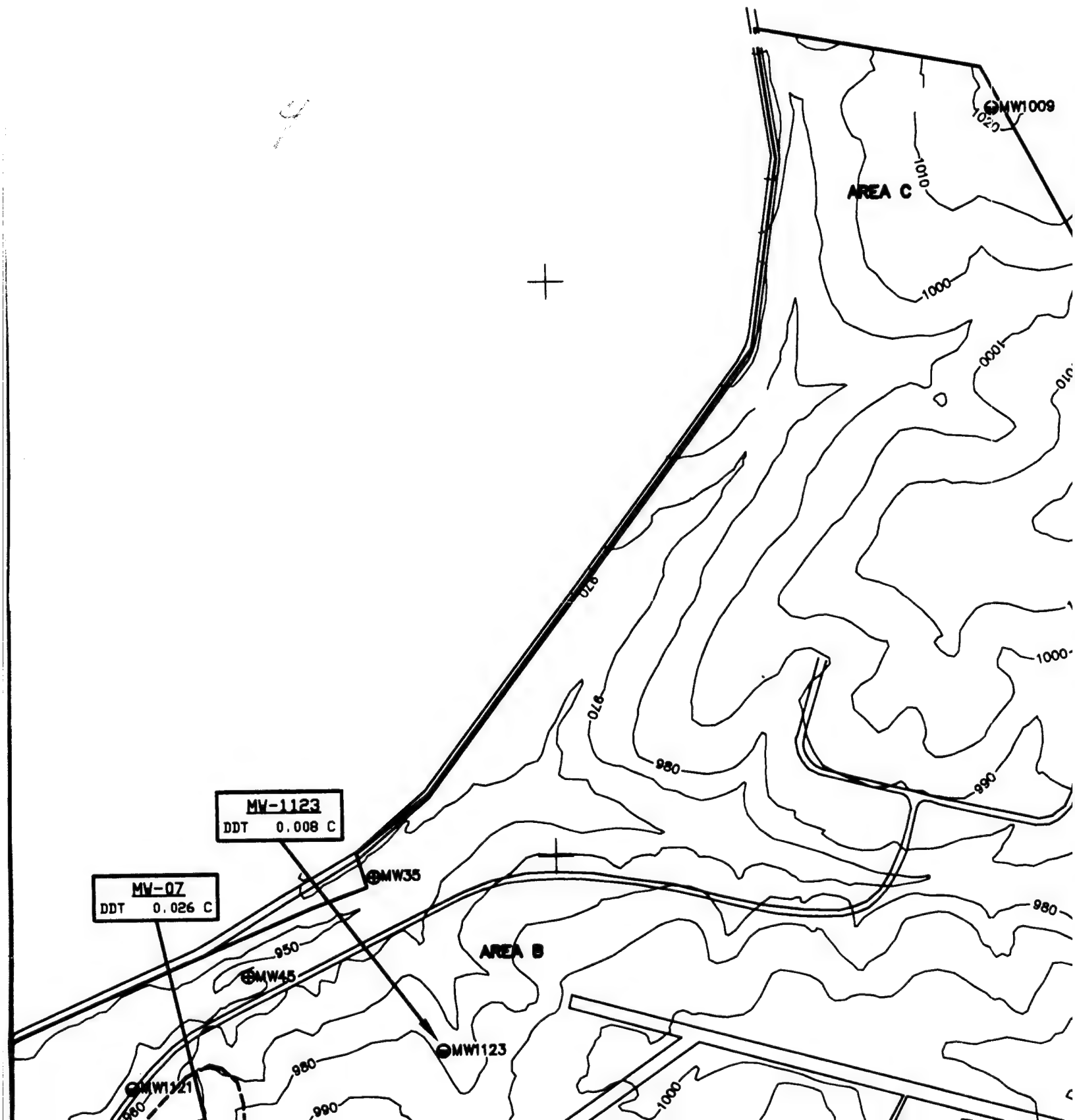
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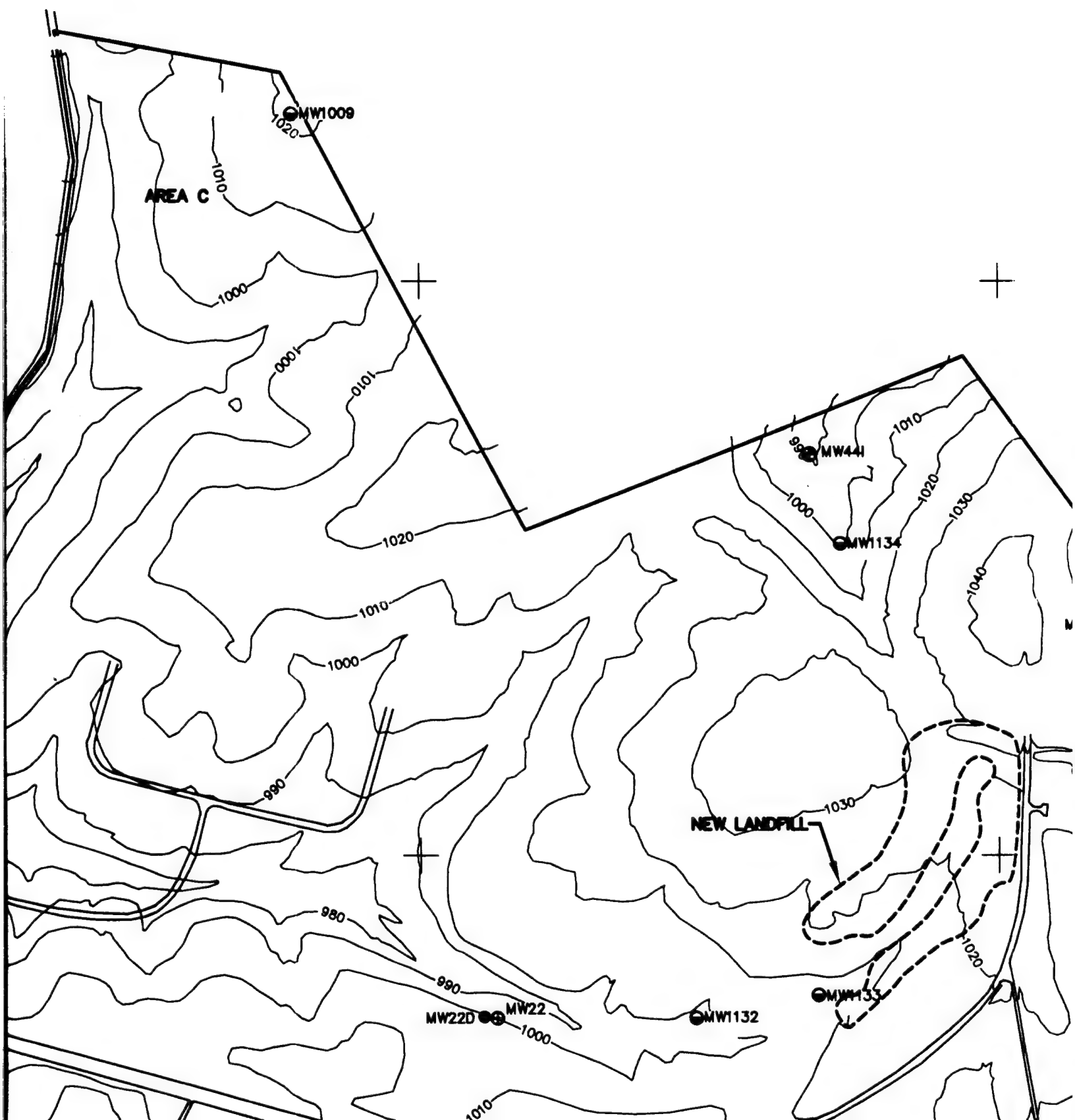
+

MW-08  
Lindane 0.006 C

350



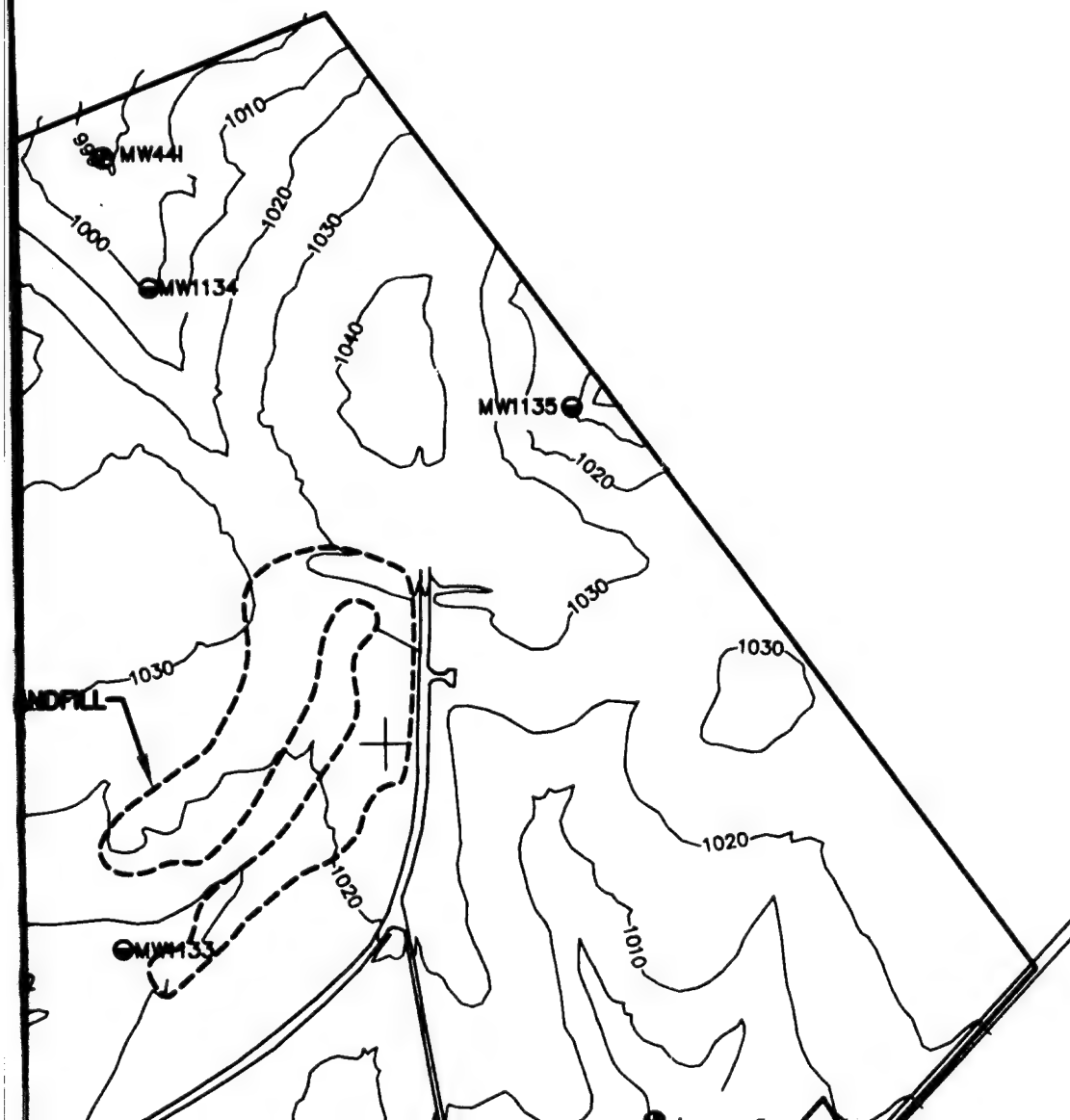






2,418,000E

13,842,000N



6

7

2,418,000E  
13,842,000N

D

C



C

6

B

13,836,000N

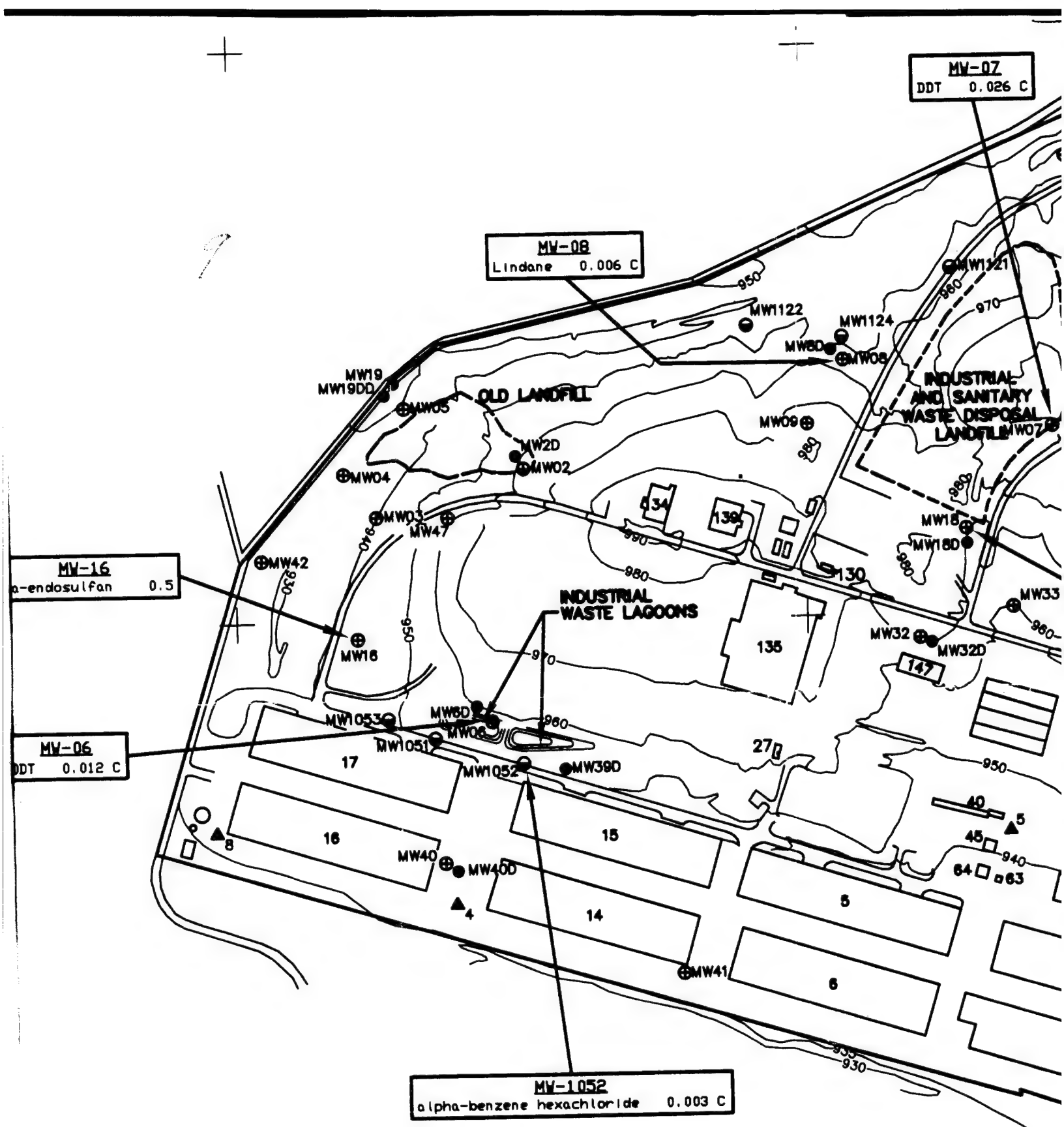
2,406,000E

MW-16  
alpha-endosulfan 0.5

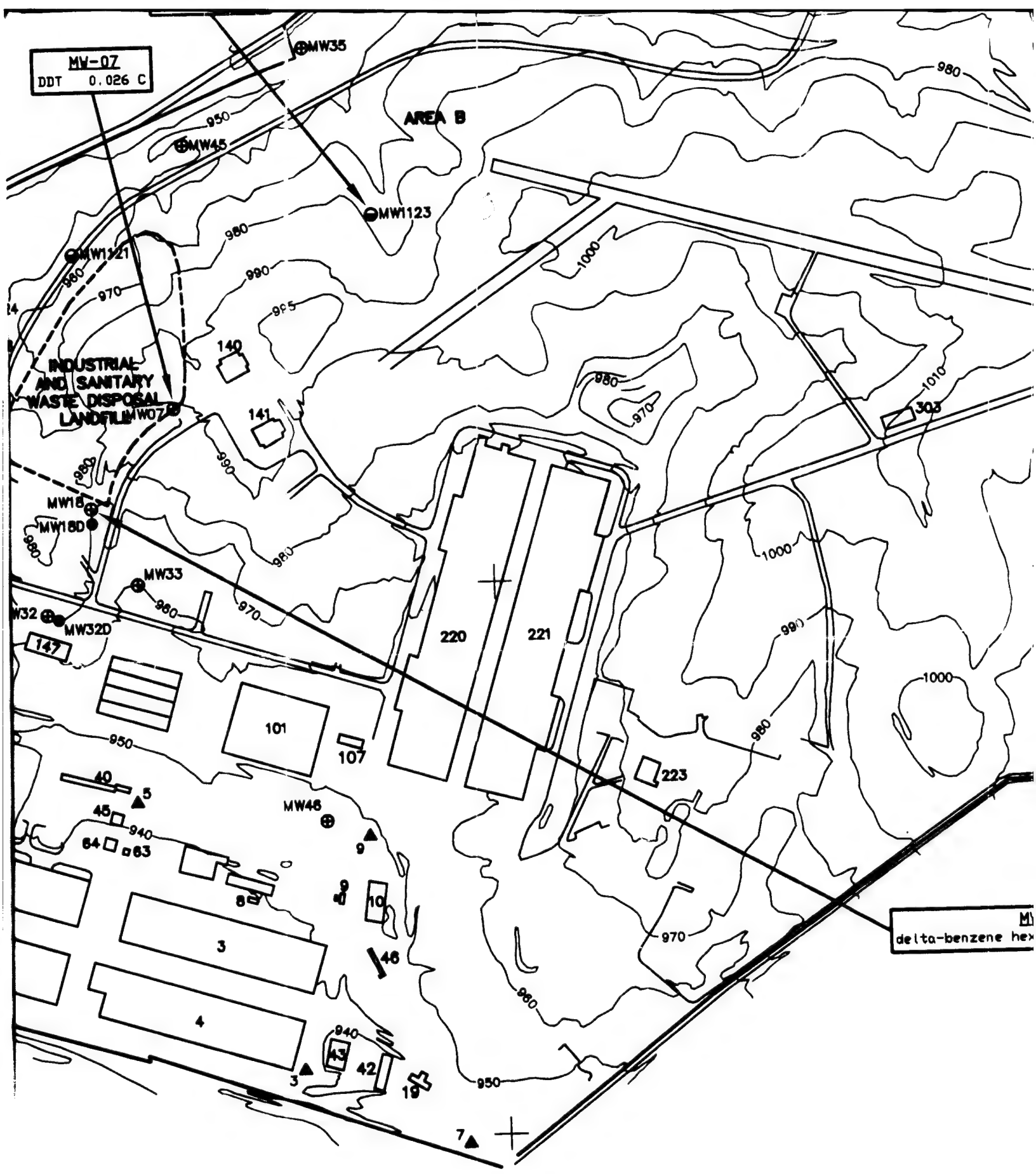
MW-06  
DDT 0.012 C

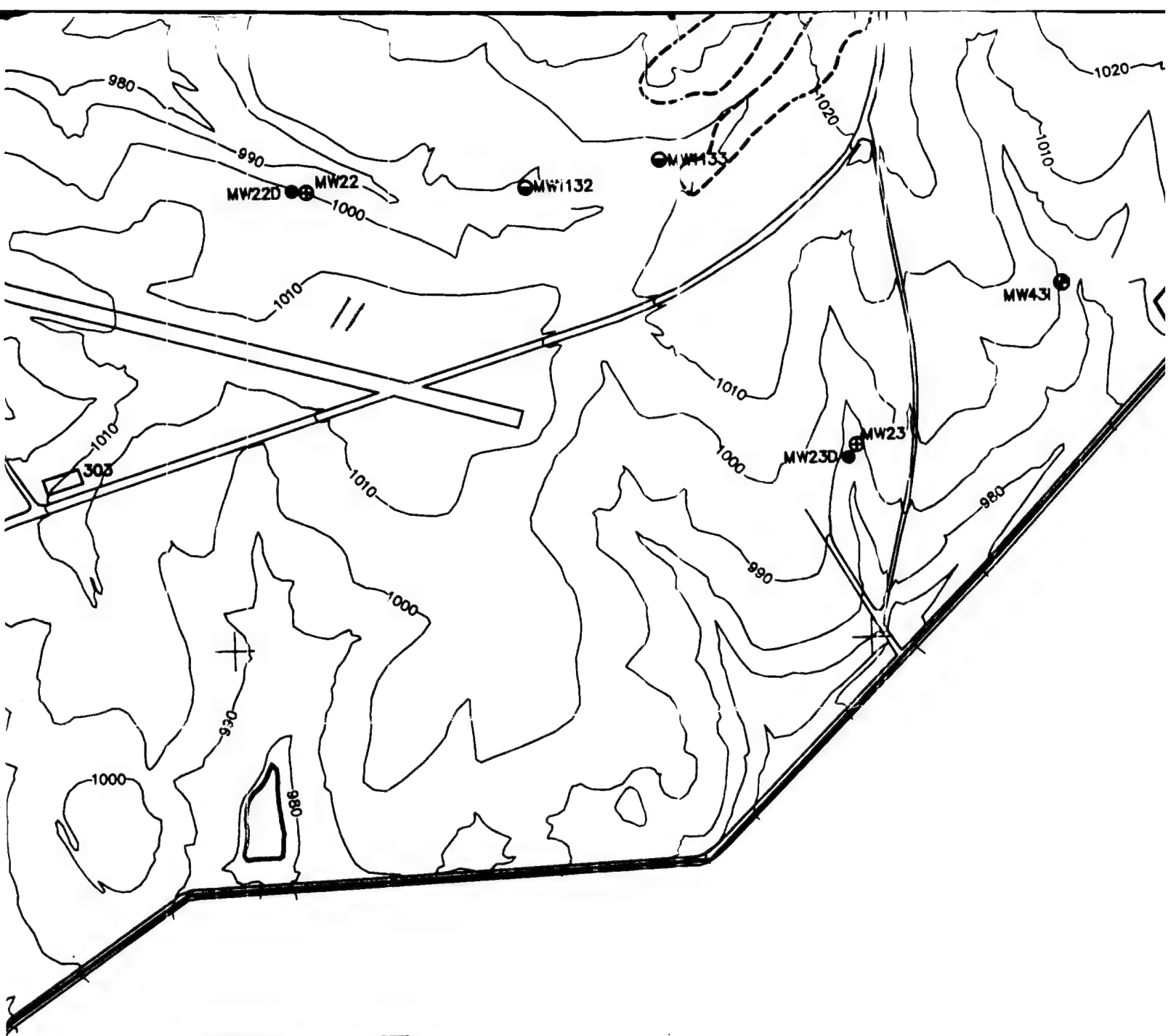
LEGEND

- EXISTING WELLS
- ⊕ SHALLOW WELLS



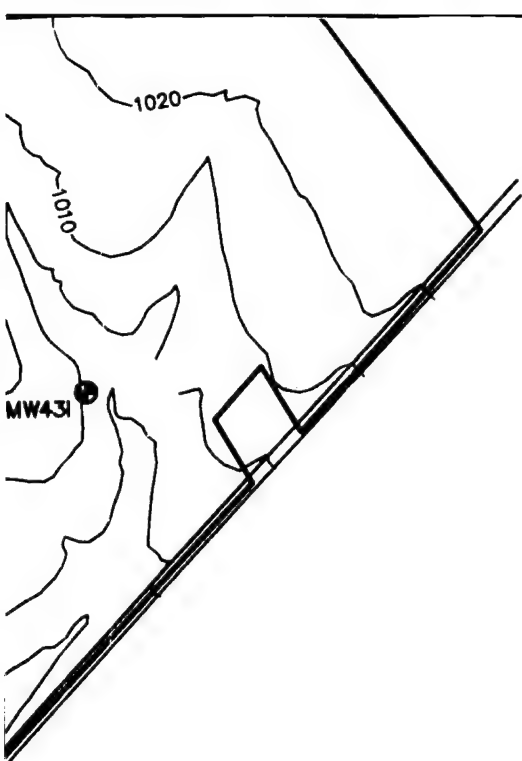
MV-07  
DDT 0.026 C





**MV-18**  
delta-benzene hexachloride 0.015 C





192

2,418,000E

13,836,000N

B

T

T

B

13

MW-06  
DDT 0.012 C



13,836,000N | 2,406,000E

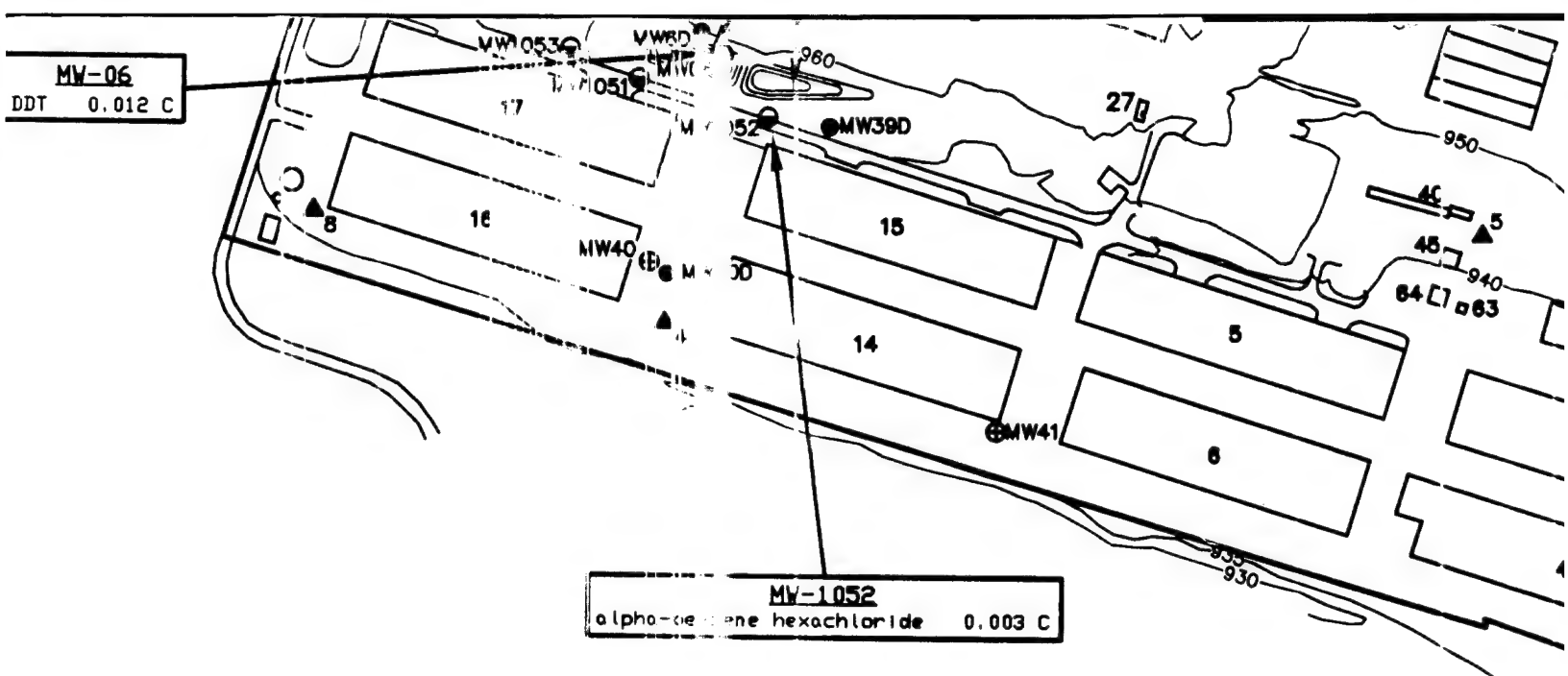
### LEGEND

- EXISTING WELLS
- ⊕ SHALLOW WELLS
- DEEP WELLS
- ⊙ BEDROCK INTERFACE WELL
- ▲ PRODUCTION WELL
- - - BOUNDARY LINE

NOTE: ALL CONCENTRATIONS IN ug/l

A

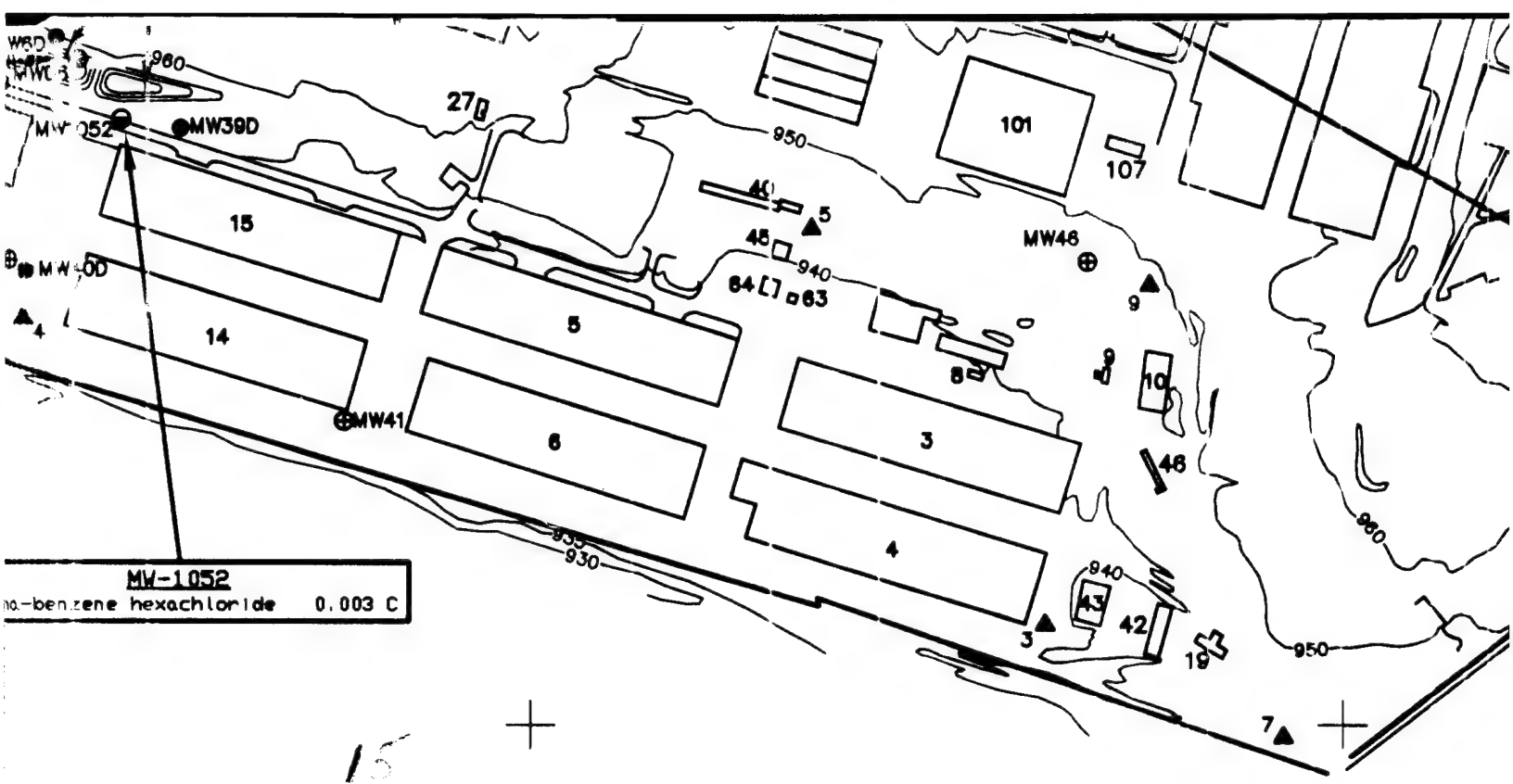
NUMBER	DATE	MADE BY	CHECKED BY	DESCRIPTION
REVISIONS				



11

ug/l

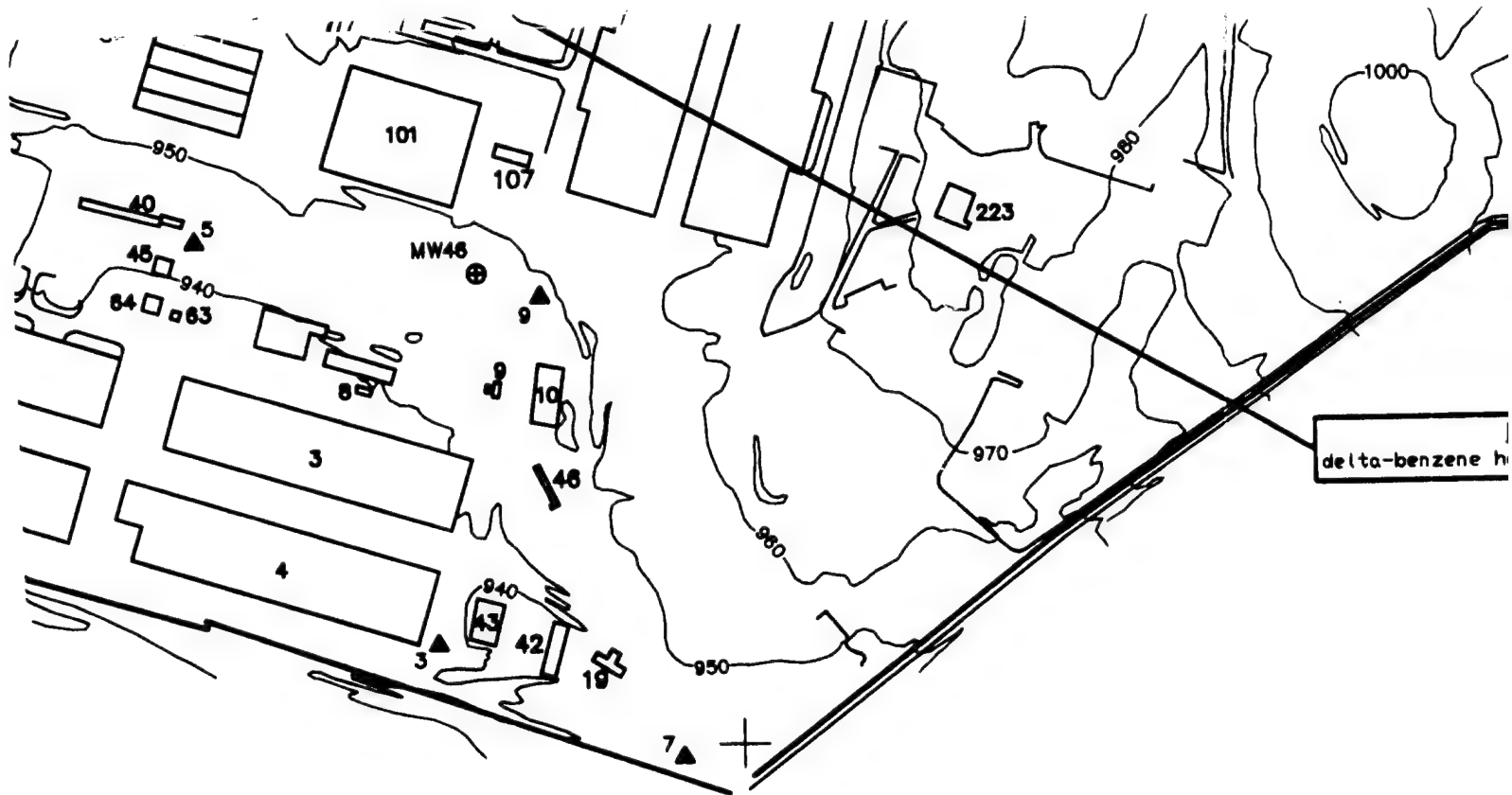
	DRAWN BY	
	CAP	
	DEPT. CHECK	
DESCRIPTION	PROJ. CHECK	



MW-1052  
no-benzene hexachloride 0.003 C

DRAWN BY CAP DEPT. CHECK PROJ. CHECK		<b>M&amp;E</b> Metc
		REG. PROF. ENGR.





**M&E**

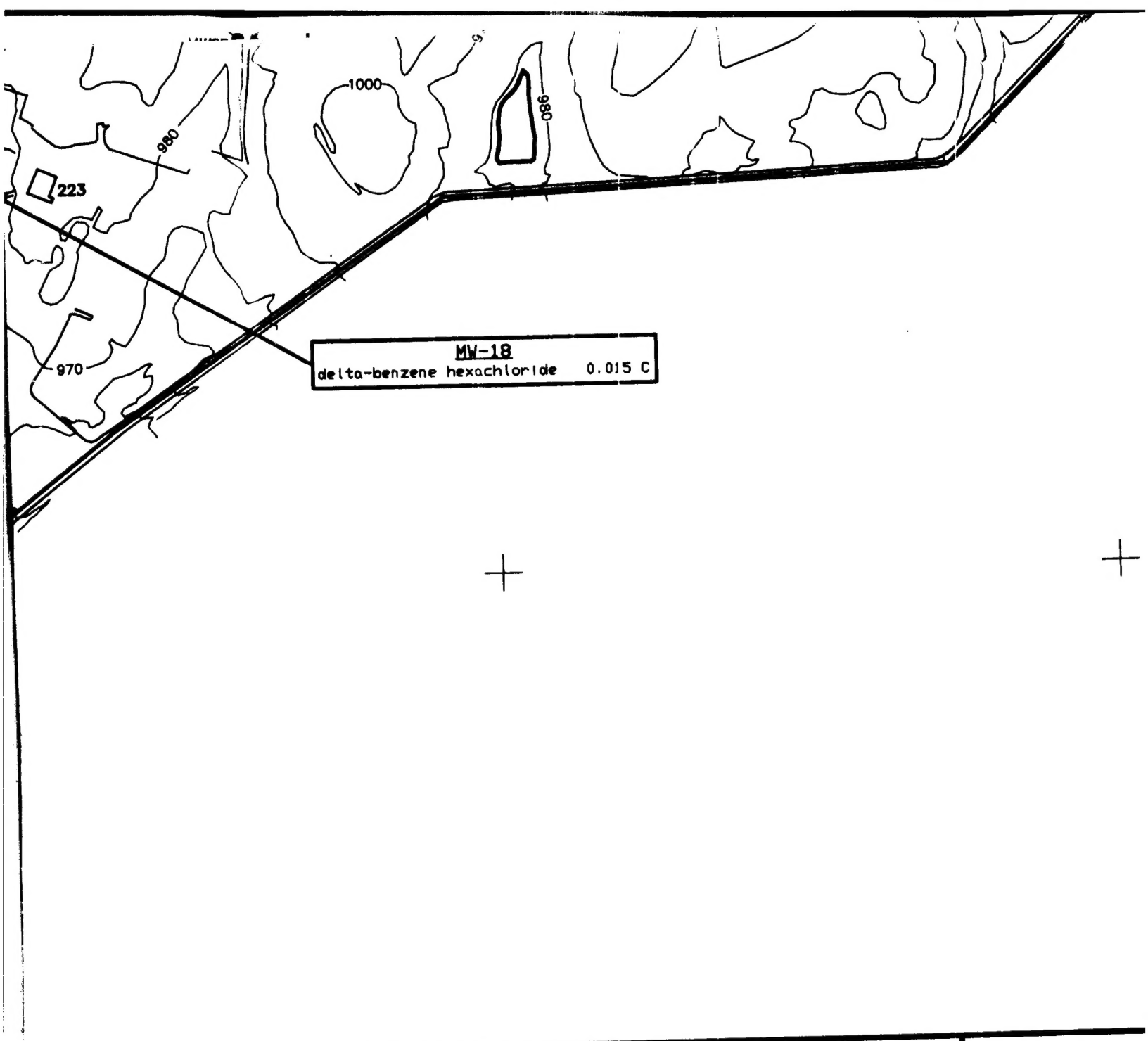
**Metcalf & Eddy**

REG. PROF. ENGR.

DATE

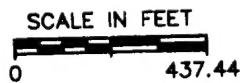
3

4



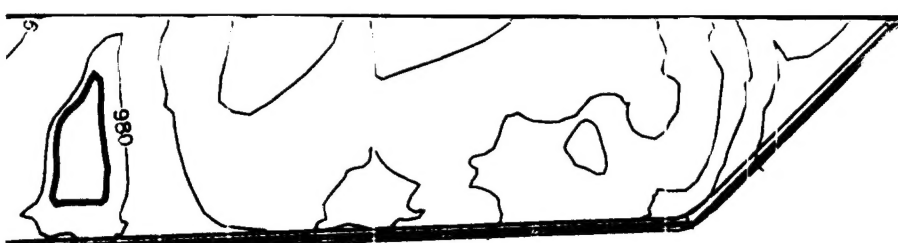
calf & Eddy

SCALE: 1" = 437.44'



DATE

UNLESS OTHERWISE NOTED OR CHANGED BY REPRODUCTION



W-18  
alachloride 0.015 C



1" = 437.44'



LEXINGTON BLUEGRASS ARMY D  
PESTICIDES DETECTED IN  
GROUNDWATER ABOVE MC  
LEXINGTON, KENTUCKY

OTHERWISE NOTED OR CHANGED BY REPRODUCTION

+

2,418,000E

13,836,000N

LEXINGTON BLUEGRASS ARMY DEPOT  
PESTICIDES DETECTED IN  
GROUNDWATER ABOVE MCLS  
LEXINGTON, KENTUCKY

JOB 012308

FILE NO. PESM

FIGURE 5-

2,418,000E

13,836,000N

B

A

EPOT

↓  
LS

JOB 012308

FILE NO. PESMAP

FIGURE 5-3